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COMPONENT, IMAGE, AND FACTOR ANALYSIS OF TESTS OF INTELLECT AND OF MOTOR PERFORMANCE.
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AN ATTEMPT WAS MADE TO DETERMINE THE EFFECTS OF CERTAIN VARIATIONS IN METHODOLOGY ON THE ANALYSIS OF EXISTING SETS OF DATA IN THE AREAS OF ABILITY OR INTELLIGENCE AND MOTOR PERFORMANCE OR PHYSICAL FITNESS. USING CURRENT DEVELOPMENTS IN THEORY AND METHODS OF FACTOR ANALYSIS DIFFERENT TREATMENTS OF VARIOUS SETS OF DATA, THREE RELATIVELY NEW MODELS WERE INCORPORATED--(1) INCOMPLETE IMAGE ANALYSIS (HARRIS, 1962-KAISER, 1063), (2) APPROXIMATION TO CANONICAL FACTOR ANALYSIS (JORESKOG, 1963), AND (3) ALPHA FACTOR ANALYSIS (KAISER AND CAFFREY, 1965). A FIRST, SYSTEMATIC EXAMINATION OF THE OPERATING CHARACTERISTICS OF THESE NEWER ASPECTS OF FACTOR THEORY WAS THUS OBTAINED. TESTED ALSO WAS AN ANALYTICAL PROCEDURE FOR OBLIQUE ROTATION THAT WAS DESIGNED TO GIVE AN UNAMBIGUOUS ANSWER TO THE QUESTIONS OF WHETHER A GIVEN SET OF VARIABLES CAN BE REASONABLY VIEWED AS A SET OF INDEPENDENT CLUSTERS (HARRIS AND KAISER, 1964). GUILFORD (STRUCTURE OF INTELLECT) AND MOTOR PERFORMANCE MATRICES, ESSENTIALLY CONSISTING OF INDEPENDENT CLUSTERS, WERE USED FOR SELECTION AND EVALUATION OF THE FACTORIAL METHODS. (JH)

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COMPONENT, IMAGE, AND FACTOR ANALYSIS OF TESTS OF INTELLECT AND OF MOTOR PERFORMANCE

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PROBLEM

Factor analysis has been used extensively to explore the dimensions of, and test hypotheses concerning, three major areas of concern: what may be called the personality-attitude-interest area, the area of abilities or aspects of intelligence, and the area of motor performance and physical fitness. For each of these areas substantive conclusions regarding the number of dimensions and the character of these dimensions are of considerable importance as basic information for education, physical education, and educational psychology. The substantive conclusions that are available from factor studies in these areas are, to some extent, dependent upon the methodology employed. Variations in rules for determining the number of factors, in the models that are employed, and in the schemes or systems for rotation that are used may introduce variations in at least the details of the findings and possibly in the general conclusions.

Developments in theory and methods of factor analysis of the last ten years now permit the examination of the effects of certain systematic variations in methodology on the analysis of a given set of data. The problem was that of determining the effects of selected variations on the analysis of certain existing sets of data in two of the three areas mentioned above. These are the areas of ability or intelligence and the area of motor performance and physical fitness. Excellent data were available in the literature for our purpose.

OBJECTIVES

The objectives of this study were to determine, for certain existing sets of data in the two areas of intellect or ability and motor performance or physical fitness, variations in the factorial results--and consequently the substantive conclusions about the dimensional characteristics of the subarea represented by the data--that are associated with two different rationales for determining the number of factors, two different definitions of the common factor space, and two different rotation procedures. This design gives "new" solutions for each set of data which can be compared among themselves and with whatever type of solution was used initially (for those matrices drawn from the literature). More is given in the section on procedures about the kinds of comparisons made.

By incorporating, in the different treatments for any one set of data, three fairly new models--incomplete image analysis (Harris, 1962; Kaiser, 1963), Joreskog's approximation to canonical factor analysis (Joreskog, 1963), and alpha factor analysis (Kaiser and Caffrey, 1965)--as well as a currently commonly used model, the comparison of results is designed to give a first systematic examination of the operating characteristics of these newer aspects of factor theory. A further objective is to test a new analytic procedure for oblique rotation that is designed to give an unambiguous answer to the question of whether or not a given set of variables can be reasonably viewed as a set of independent (but possibly correlated) clusters (Harris and Kaiser, 1964). The Guilford data we drew upon represents the interrelationships of variables skillfully constructed to tap or represent, in each instance, a certain portion of his model of the Structure of Intellect. Given measurement procedures that are derived from such a rationale, it seems likely that the factorial results should be consistent with the notion of independent (but possibly correlated) clusters of variables. Our new procedure enabled us, analytically and objectively, to test this hypothesis for each of the sets of data we examined. Similarly, in the area of motor performance, a reasonable a priori model for the selection of variables exists, and this model, too, is essentially one of independent clusters. Thus, for both types of data, application of our new rotation procedure enabled us to test an important hypothesis that bears directly on the underlying models in the two areas.

RELATED RESEARCH

No attempt is made here to survey the literature on factor analysis. The volume by Harman (Harman, 1960) is a general guide to developments up to that time. Neither will we cite in detail the work of Louis Guttman, whose theoretical developments have been influencing the literature on factor analysis. Guttman's influence is explicitly cited in papers by Harris (Harris, 1962; Harris, 1963) and by Kaiser (Kaiser, 1963) that are basic references for this problem. In addition, recent work by Kaiser and Caffrey (Kaiser and Caffrey, 1965), Harris and Kaiser (Harris and Kaiser, 1964), and Joreskog (Joreskog, 1963) are basic references. Still another paper by Harris (Harris, 1964) summarizes our view of the major variations in factor analysis technique. Some of these are the variations whose effects we have studied.

A second type of literature that is relevant is that dealing with the notions of abilities or intellect. Like the literature on factor analysis, this literature also is voluminous, dating back to the early work of Stern, Binet and Simon, Goddard, Terman, etc. Since, as we shall state below, we utilized data gathered by Guilford in his studies of the model that he developed under the heading of the Structure of Intellect (Guilford, 1956, 1959), we cite in the references only these published articles by Guilford and certain unpublished laboratory reports from the University of Southern California issued by Guilford and his colleagues. From these reports we took existing data for study in this project.

A third set of relevant literature exists; this is the literature on the measurement of motor performance and physical fitness. Again, a lengthy survey would be required to abstract this literature adequately. The relevant literature that is specific to the problem we studied consists of papers by Fleishman and his colleagues (Fleishman _et_ _al_., 1961a; Fleishman _et_ _al_., 1961b), Cousins (Cousins, 1955), Cumbee (Cumbee, 1954, Brogden and his associates (Brogden _et_ _al_., 1952), McCraw (McCraw, 1949), Phillips (Phillips, 1949), and Wendler (Wendler, 1938). The data for this portion of the study came from these sources and from two unpublished studies by Liba.

PROCEDURE

Eight correlation matrices of motor performance variables developed by other investigators were selected for study. In addition, two correlation matrices developed from data gathered at the University of Wisconsin were selected. These matrices are identified in Table 1 and their sources given in the list of references. Nine correlation matrices originally reported in seven of the reports from the Psychological Laboratory of the University of Southern California were selected for study. Each of these sets of data was developed originally by Guilford and his associates. These matrices are identified in Table 2 and their sources given in the list of references.

The methods of developing an initial solution will be described in matrix notation. First we establish these four definitions:

R. The observed correlation matrix with units in the main diagonal, of order p-by-p.

F An initial factor (or component) matrix. The definition of F depends upon the model and is made explicit below for each of the models considered here. F always has p rows; the number of its columns equals the number of factors (or components) extracted.

S^2 A diagonal matrix of order p-by-p, with non-zero entries each equal to the reciprocal of the corresponding diagonal element of R^{-1}. Thus, $I - S^2$ is a diagonal matrix of squared multiple correlations of each variable with the remaining p-1 variables.

H^2 A diagonal matrix of order p-by-p, whose non-zero entries are the communalities. For Models A and D, H^2 is computed after the fact and does not enter into the initial determination of the factors (or components). For Model B the first stage is one of selecting trial communality values and converging these to reasonably stable values under a restriction on the number of factors. For Model C, $U^2 = I - H^2$ is taken as proportional to S^2.

Next, we define the four models employed in terms of these definitions as:

Model A This is an incomplete principal components solution of R. The criterion for the number of components to extract is Guttman's "weak" lower bound to the number of common factors (Guttman, 1954). This is the number of eigenvalues of R that exceed unity. For this model, $F = QD$, where Q designates orthonormal columns of eigenvectors of the matrix R, and D is a diagonal matrix of the positive square roots of the eigenvalues greater than unity of this same matrix.

Model B This is alpha factor analysis (Kaiser and Caffrey, 1965). $F = HQD$, where H is as defined above, Q designates orthonormal columns of eigenvectors of the matrix $H^{-1}(R - U^2)H^{-1}$, and D is a diagonal matrix of positive square roots of the eigenvalues greater than unity of this same matrix. The F for Model B has the same number of columns as does the F for Model A.

Model C This is Joreskog's procedure (1963), which determines a constant, t, on the basis of a statistical test and then takes $U^2 = I - H^2$ as tS^2. The number of factors is also determined by the statistical test. The factor matrix is given by $F = SQD$, where S is as defined above, Q designates orthonormal columns of eigenvectors of $S^{-1}RS^{-1}$, and D is a diagonal matrix of positive square roots of the eigenvalues of $S^{-1}RS^{-1} - tI$. Model C has certain correspondences with Model D.

Model D This is related to Guttman's image theory (Guttman, 1953; Harris, 1962; Kaiser, 1963). $F = SQD$, where S is as defined above, Q designates orthonormal columns of eigenvectors of the matrix $S^{-1}RS^{-1}$, and D is a diagonal matrix of positive square roots of the positive eigenvalues of the matrix $S^{-1}RS^{-1} - I$. Thus, the number of factors extracted equals Guttman's "strong" lower bound. This factor matrix can be modified, by modifying D, to yield an incomplete image analysis.

In addition to securing an initial solution for each of these models, we secured a derived orthogonal solution, using the Kaiser normal varimax procedure (1958), for each of the four initial solutions for each matrix. A derived oblique solution, using the Harris-Kaiser independent cluster model (1964), was secured for the initial solutions by Models A, B, and C for each matrix. Since the initial solutions for Models C and D are proportional by columns, the derived oblique solution for Model D for the same number of factors would be identical with the Model C solution.

Table 1

Operating Characteristics, Motor Performance Matrices

Matrix	p	N	Model A m	Model A f	Model A mean h^2	Model B m	Model B f	Model B mean h^2	Model C m	Model C f	Model C mean h^2	Model C t	Model D m	Model D f	Model D mean h^2
Brogden	23	217	5	.0028	.67	5	.0013	.58	12	.0001	.71	.70	13	.0003	.65
Cousins	31	116	9	.0028	.67	9	.0013	.54	10	.0010	.56	1.03	20	.0003	.63
Cumbee	21	200	6	.0048	.57	6	.0010	.41	5	.0017	.36	.94	11	.0006	.41
Fleishman-Speed	30	204	9	.0032	.61	9	.0010	.45	10	.0008	.47	.90	18	.0005	.48
Fleishman-Strength	30	201	7	.0024	.66	7	.0009	.55	9	.0005	.59	.90	17	.0002	.61
McCraw	15	100	3	.0059	.54	3	.0022	.43	2	.0032	.38	1.01	8	.0008	.48
Phillips	24	200	6	.0034	.62	6	.0012	.49	9	.0005	.56	.85	14	.0004	.55
UW-Balance	31	53	11	.0028	.73	11	.0014	.59	4	.0070	.35	2.02	21	.0002	.71
UW-Strength	29	52	9	.0021	.78	9	.0013	.68	11	.0007	.73	1.16	19	.0001	.80
Wendler	30	120	4	.0014	.72	4	.0009	.67	6	.0006	.70	1.08	17	.0001	.76

p = No. variables
N = No. subjects
m = No. factors
f = average squared residual correlations
Mean h^2 = average communality
t = Joreskog constant

Table 2

Operating Characteristics, Guilford Matrices

			Model A			Model B			Model C				Model D			Guilford Original Solution	
Matrix	p	N	m	f	mean h^2	m	f	mean h^2	m	f	mean h^2	t	m	f	mean h^2	m	mean h^2
08	53	410	14	.0017	.59	14	.0005	.45	19	.0003	.50	.88	28	.0002	.49	16	.46
09	47	397	15	.0021	.68	15	.0010	.53	**	**	**	**	39	.0001	.80	16	.54***
12	52	364	13	.0018	.56	13	.0005	.42	7	.0010	.35	1.05	30	.0002	.45	17	.44
14	23	176	6	.0044	.57	6	.0011	.42	4	.0019	.37	1.01	13	.0005	.45	10	.48
16A	28	200	6	.0028	.57	6	.0010	.45	4	.0015	.41	1.01	16	.0003	.50	12	.53
16B	26	200	6	.0032	.57	6	.0008	.44	4	.0014	.40	1.00	14	.0003	.47	12	.51
16C	26	200	6	.0035	.58	6	.0012	.45	6	.0011	.45	.96	14	.0004	.50	12	.54
22	42	232	12	.0023	.60	*	*	*	7	.0015	.36	1.07	24	.0003	.48	14	.46
23	30	240	5	.0025	.53	5	.0010	.44	5	.0011	.44	.99	17	.0003	.51	15	.55

p = No. variables
N = No. subjects
m = No. factors
f = average squared residual correlation
Mean h^2 = average communality
t = Joreskog constant

* Did not converge
** Went to p-1 factors
*** Omitting one variable

FINDINGS: TECHNICAL ASPECTS

The major findings concerning the operating characteristics of each of the models used are given in Tables 1 and 2. Specifically, we observe:

1. A measure of fit of the initial solution to the original correlations (defined as the average squared residual correlation) indicated: (a) fairly consistent fit for a given model across the two domains of motor performance and intellect, and (b) consistent differences among models.

2. For incomplete principal components and for alpha, both of which extract the same number of factors, the measure of fit was markedly superior for alpha. This was to be expected on theoretical grounds.

3. The incomplete image analysis yielded the best fit, but this model extracts more factors than does alpha since it employs the strong lower bound of Guttman whereas alpha employs the weak lower bound.

4. The incomplete principal components model extracts a greater proportion of the total variance than does alpha. Again, this would be predicted on theoretical grounds.

5. Incomplete image analysis also extracts a greater proportion of the total variance, utilizing more factors, than does alpha. There were no consistent differences between the incomplete principal components and the incomplete image in the proportion of variance extracted.

6. For more than half of the matrices, the Joreskog procedure yielded a multiplying constant greater than unity when in theory this constant should not be that large. This suggests that the Joreskog procedure may not be completely satisfactory for general use.

7. In one instance, the alpha procedure did not converge. In another instance, the Joreskog procedure failed to stop before extracting n-1 factors; such a solution is trivial and was discarded. (See Table 2.)

8. The number of initial factors extracted tends to be spanned at the low end by alpha and the incomplete principal components and at the high end by incomplete image analysis. However, the Joreskog procedure does not always fall within this range, even when we ignore the matrices for which the multiplying constant was greater than unity.

In Tables 3 and 4 we summarize the arbitrarily defined effective number of factors. This number was determined by counting the number of factors in the derived orthogonal solution for which at least one variable has a coefficient of .30 or greater. From these tables and from comparison of their entries with corresponding entries in Tables 1 and 2, we observe:

1. For Models A and B the effective number of factors is almost always equal to the initial number of factors. For Model D the effective number of factors tends to be the largest such number for any matrix.

2. In a number of instances the range in effective number of factors over the four models tends to be large.

3. For the Guilford matrices, no one of the four models consistently gave the same number of effective factors as Guilford secured. However, incomplete image analysis (Model D) tended to give as many or more. Models A and B tended to give fewer factors than Guilford had identified.

In Tables 5 and 6 we summarize the effective number of common factors, defined arbitrarily as the number of factors in the derived orthogonal solution for which at least two variables have coefficients of .30 or greater (absolute). From these tables, we observe:

1. For any matrix, the range in the effective number of common factors, over models, is substantially less than the range in the number of initial or of effective factors. This reduction in range is primarily a function of changes associated with Model D for both types of data.

Table 3

Effective Number* of Factors

Motor Performance Matrices

Matrix	Model A	Model B	Model C	Model D
Brogden	5	5	11	9
Cousins	9	9	10	17
Cumbee	6	6	5	8
Fleishman-Speed	9	9	10	15
Fleishman-Strength	7	7	9	13
McCraw	3	3	2	6
Phillips	6	6	9	11
UW-Balance	11	11	4	19
UW-Strength	9	9	11	16
Wendler	4	4	5	11

---

*Defined arbitrarily as the number of factors in the derived orthogonal solution for which at least one variable has a coefficient of .30 or greater.

Table 4
Effective Number* of Factors
Guilford Matrices

Matrix	Model A	Model B	Model C	Model D	Guilford
08	14	14	18	23	15
09	15	15	**	38	16
12	13	13	7	21	14
14	6	6	4	11	9
16A	6	6	4	11	11
16B	6	6	4	9	9
16C	6	6	6	11	10
22	12	**	7	20	13
23	5	5	5	12	13

*Defined arbitrarily as the number of factors in the derived orthogonal solution for which at least one variable has a coefficient of .30 or greater.

**Solution did not compute.

Table 5

Effective Number of Common Factors,* Motor Performance Matrices

Matrix	Model A	Model B	Model C	Model D
Brogden	5	5	8	6
Cousins	9	9	9	12
Cumbee	6	6	5	7
Fleishman-Speed	9	9	9	10
Fleishman-Strength	7	7	8	7
McCraw	3	3	2	5
Phillips	6	6	8	8
UW-Balance	11	11	4	9
UW-Strength	9	9	11	10
Wendler	4	4	4	5

---

[*] Defined arbitratily as the number of factors in the derived orthogonal solution for which at least two variables have a coefficient of .30 or greater (absolute).

Table 6

Effective Number of Common Factors,* Guilford Matrices

Matrix	Model A	Model B	Model C	Model D	Guilford
08	14	11	15	10	15
09	14	13	**	13	14
12	13	10	7	8	14
14	6	6	4	7	9
16A	5	5	4	7	11
16B	6	6	4	7	9
16C	6	6	5	8	10
22	12	**	7	8	13
23	5	5	5	7	13

*Defined arbitrarily as the number of factors in the derived orthogonal solution for which at least two variables have a coefficient of .30 or greater (absolute).

**Solution did not compute.

2. For both the motor performance and the Guilford matrices, Model D tends to extract an initial number of factors equal to 6/10 the number of variables. This is consistent with earlier observations. For the motor performance matrices the effective number of common factors associated with Model D tends to approximate 1/4 to 1/3 the number of variables. For the Guilford matrices, the effective number of common factors tends to approximate 1/4 the number of variables.

3. For the Guilford matrices, in every instance except one, the effective number of common factors for each of the four models was less than the corresponding number of factors interpreted by Guilford, using the same rule of two or more variables with coefficients of .30 or greater.

4. For five of the Guilford matrices, each consisting of from 20 to 30 variables, the effective number of common factors ranged from four through eight, but was markedly consistent within a model across matrices. For the four matrices each with more than 40 variables, a larger effective number of common factors was found.

FINDINGS: MOTOR PERFORMANCE MATRICES

Many of the eight matrices which were available in the literature included test items which could not be classified as motor performance variables (anthropometric measures such as height, weight, etc.) and also included some composite variables (strength index, a composite of grip plus back--plus leg--strength). These variables were not included in the matrices when the data were analyzed for this study. Thus the number of variables in the matrices as analyzed in this study frequently was less than the number in the original study.

The variables which were used could be categorized a priori into four large groups representing somewhat similar performance as follows: tests which involved the projection of the body (as in a jump or run); tests in which an object is projected (softball throw or medicine ball put); tests in which the body weight is moved or supported against the pull of gravity (as in the push-ups or the dips); and tests in which strength is measured by an instrument (grip strength, back strength). These four categories encompass the majority of the test variables in the 10 matrices.

The results for each of the 10 motor performance matrices will be presented separately. One of the derived solutions for each of the 10 matrices is given in the appendix in table form. The reader may refer to these to find the numerical values upon which the discussion is based. Since there is considerable similarity for the various solutions (with the exception of Model C)--the major difference being in the level of specificity of the factors--the solution selected for inclusion in the appendix serves as a sample solution for that particular matrix.

Only limited comparisons are made with the original studies because of the necessity for eliminating some of the variables included in the original studies.

Brogden Matrix

There are 31 variables in the original study; 23 of these were motor performance items and were included in this study. Twelve of the 23 were body-projection items; four involved tests for moving or supporting the body weight against gravity; four were object-projection tests; and the remaining three were the Burpee, the ankle-to-bar, and the sit-ups.

The results for the seven solutions obtained in this study will be presented and discussed as two groups of solutions. The first group will include the derived orthogonal and derived independent cluster solutions for Models A and B. For these two models there were five effective factors. The second group will include the derived orthogonal solutions for Models C and D and the derived independent cluster solution for Model C. The number of effective factors in these solutions was approximately the same--11, 12, and 9, respectively. The solution selected for the appendix is the derived orthogonal solution for Model B.

Models A and B

For these four solutions, one factor is essentially identified by five of the body-projection items (5, 6, 7, 8, and 9). Three of these are measures of jumping ability. Item 8 is the hop-step-jump and although not a pure jump measure does involve jumping ability. Item 9 is the vault and, although the hands are used for support in the vault, the test does involve projection of the body into the air as in a jump. There are some additional variables which load on this factor and they vary somewhat over the four solutions.

A second factor is identified by three of the test items for moving the body weight (18, 19, and 22). The sit-ups (21) also has its highest loading on this factor. Since the upper body mass is lifted against gravity in performing the sit-ups, this finding is not unusual. In the two derived orthogonal solutions, the ankle-to-bar has its highest loadings on this factor also, but in the derived independent cluster solutions this item goes with the factor involving quick changes of body direction. Its appearance on both factors seems justified since the lower body mass is lifted against gravity and directional change in the body segments must be made rapidly. There is no clear location for this item. Three additional items appear on this factor in the two derived orthogonal solutions (17 and 20 in Model A and 17 in Model B), and there is a small negative loading for the 100-yd. shuttle (16) in the two derived independent cluster solutions.

A third factor is identified by the four object-projection tests (1, 2, 3, and 4) with some additional items appearing on this factor in the two derived orthogonal solutions. The factor is more clearly identified as object-projection in the two derived independent cluster analyses.

A fourth factor is identified primarily by four of the body-projection items (13, 14, 15, and 16) and all of these are items involving quick changes of body direction while running. Item 20, the Burpee test, has its highest loading on this factor in three of the solutions and is represented on the factor in the fourth. This finding seems reasonable since the Burpee test involves quick changes of direction of body segments; there is, however, no locomotion involved. The loading of the ankle-to-bar test has already been commented on. Other items appear with different coefficients in the four solutions.

The variables which have their highest loadings on the fifth factor are all body-projection items (10, 11, and 12) and all involve a straight run over a distance of at least 50 yards. Thus this set can be differentiated from the runs which involve a short straight run (no more than 20 yards) plus quick change of body direction. These latter items do load to some extent on this factor however, and would support the notion of calling this a performance on the straight run. In addition, other items appear to some extent and this varies over the four solutions.

In summarizing the results for these four solutions, the 12 test items of body projection load on three factors which might be identified as jumps, straight runs, and quick changes of body direction while running. There is a factor associated with the items testing the ability to move the body weight against gravity although the rope climb item is not associated with this factor. Finally, there is clearly an object-projection factor.

Models C and D

One of the factors in the two orthogonal solutions is identified by five of the body-projection items (5, 6, 7, 8, and 9)--the three jump tests, the hop-step-jump, and the vault. Item 9 is also specific to a single factor in the orthogonal solution for Model D. These results are comparable to those found in the four solutions previously discussed, except for the specific factor reported for item 9. However, the derived independent cluster solution for Model C gives a different representation of the data. There is a factor identified by test items 7 and 9--the broad jump and the hop-step-jump and item 16--100 yd. shuttle (20-yd. laps). There is a factor on which the vault appears (item 8) and variable 20 has a negative loading; there is a factor on which the standing broad jump (item 6) has a substantial loading with some of variables 7, 15, 19, and 21 (21 is negative), and the vertical jump (item 5) loads on another factor with the sit-ups. Thus for the derived independent cluster solution for Model C, there is a breaking up of the jump-type tests into two smaller clusters and two factors on which the jump-type tests also appear. There are also some additional test items loading to varying extents on these factors in the three solutions, and there are some negative loadings for the factors in the derived independent cluster solution.

The variables which test the ability to move or support the body weight against gravity have the same representation in the two orthogonal solutions for Models C and D. There are two factors. One of these includes the chin, push-ups, dips, and ankle-to-bar (items 18, 19, 22, and 23) and the Burpee and sit-ups have their highest loadings on this factor for Model D and are represented on the factor with smaller loadings in Model C. In the latter solution, however, items 20 and 21 have their highest loadings on other factors. These same items are also specific to factors in Model D, but the loadings are small. Item 23, ankle-to-bar, is also represented as a specific factor to the extent of .44 in Model C. The second factor for these test items in the two orthogonal solutions is represented by the rope climb (item 17) and the chins (item 18) also loads here but not as high as on the factor just described. In addition, the vertical jump (item 5) is represented on the factor to some extent in both solutions as is the obstacle race (item 15) in the solution for Model D.

The representation of these test variables in the derived independent cluster solution for Model C, however, is somewhat different. It is similar in that there is a factor on which the rope climb (item 17) as well as the chins (item 18) with small loadings for the vertical jump (item 5) and the obstacle race (item 15) are represented. This duplicates one of the factors obtained in the two derived orthogonal solutions. It is dissimilar in that for this solution three additional factors are obtained: the push-ups and dips (items 19 and 22) load on one of the factors; there is a factor represented by the ankle-to-bar test (item 23), with some of 14 and 21; and there is a factor which is either specific to the Burpee (item 20) or to the vault (item 9). Both of these have their highest loadings on this factor; one is positive and one is negative.

For two of the solutions--the derived orthogonal for Models C and D--the representation of the object-projection items is identical. The softball throw, medicine ball put, medicine ball throw, and basketball throw (items 1, 2, 3, and 4) have their highest loadings on a single factor. Three additional items have small loadings here--the standing broad jump, the hop-step-jump, and the 300-yd. run (items 6, 9, and 10). For the derived independent cluster solution for

Model C, however, these four object-projection items break up into two small clusters with the softball throw and basketball throw on one factor and the two medicine ball items on a second. This appears reasonable since the medicine ball is a heavy object to be projected whereas the softball and basketball are much lighter in weight. It is conceivable that the distinction is associated with the strength demands of projecting objects of such different weights.

The factor solution for the items measuring the runs is similar for the two orthogonal solutions for Models C and D. The 300-yd. run, the 100-yd. shuttle (50-yd. laps), the 250-yd. shuttle (50-yd. laps), and the 100-yd. shuttle (20-yd. laps) (items 10, 11, 12, and 16), are all represented on a single factor. For both solutions, items 9 and 14, the hop-step-jump and the hurdle run also have small loadings. In addition, the 100-yd. shuttle has a substantial loading on another factor and is associated with the test items measuring the quick change of body direction during locomotion. The appearance of all four of these test items on the same factor seems to be justifiable since all involve a run of at least 100 yards. However, the fact that item 16 in which the 100-yard run is broken up into shorter 20-yard laps also loads on the quick change of direction factor appears to be equally defensible. For the independent cluster solution for these variables for Model C, three factors are needed. In this analysis, item 16--the 100-yd. shuttle--appears on a different factor loading with the broad jumps and the hop-step-jump. The reason for this is not clear. The longest run (item 10) is specific to a single factor in this solution and items 14 and 15--hurdle run and obstacle race--have small negative loadings on this factor. Finally, items 11 and 12 (100-yd. shuttle and 250-yd. shuttle, both in 50-yd. laps) appear together on a single factor with item 15, the obstacle race, being represented to some extent as well.

An interesting result is obtained for the runs involving a quick change of body direction. Whereas for the previous factors discussed, the two orthogonal solutions had similar representations differing somewhat from the independent cluster analysis, in this case the orthogonal solution for Model C is different from the two other solutions. For the derived orthogonal solution for Model C the dodge run (item 13) is specific to a factor and the hurdle run and obstacle race (items 14 and 15) have their highest loadings on one factor. The three items are grouped on a single factor in both the derived orthogonal solution for Model D and the derived independent cluster solution for Model C. Item 16 has a loading of .40 on this factor also in the orthogonal solution for Model D although it has a slightly higher loading on the run factor.

In summary, except for the last factor described, the representation of the test variables was similar for the two orthogonal solutions. The independent cluster solution for Model C suggested a different representation of the variables--in most instances there was a breaking up into smaller clusters or specific factors for variables which were grouped in the two orthogonal solutions.

Summary

In comparing the two sets of solutions, in general, the orthogonal solutions in the second group were identical or quite similar to the solutions presented for the first group when the three large categories of test items are considered. Thus there tended to be three factors representing the body-projection items, a factor for moving the body weight, and a factor for object-projection. An exception here must be noted. The rope climb item was most clearly explained in the solutions in which a greater number of factors were extracted--Models C and D--in that in all instances it emerged as a separate factor. The three remaining test items--Burpee, ankle-to-bar, and the sit-ups--appeared most often on factors specific to the particular item in the second group of orthogonal solutions thus accounting for the larger number of factors obtained. The independent cluster solution for Model C, however, was not similar to the other six and this comparison was made in the previous paragraph.

Comparison With the Original Solution

A comparison with the original solution by Brogden, Burke, and Lubin is somewhat hazardous since only 23 of the original 31 variables were included in the analyses in this study. Some comments seem pertinent, however. Data for the 31 variables were factored in the original analysis employing Thurstone's Group Centroid Method. This procedure yielded eight factors. Where the factor plots indicated correlation between two clusters of tests, a rotational technique was used employing an additional orthogonal axis. The final solution presented had 12 factors; two of these were represented by variables not included in this study. Five of the remaining 10 were the same factors found in the six solutions in this study for which the results were similar. Another factor in the original analysis included the rope climb and chins and this was the sixth factor that appeared prominently in three of the solutions in this study. The remaining four factors in the original analysis are broad factors named by the authors as mobilization, endurance, leg general, and arm extension. These were not reproduced in the analyses in this study. Thus the results in the analyses in this study tend to support the existence of the factors associated with such performances as object-projection, runs, jumps, broken runs or quick changes of body direction, and moving the body weight against gravity differentiated as to pulling and pushing. The results in this analysis do not support the existence of the factors associated with more general performance as identified in the original study.

Cousins Matrix

Thirty-one of Cousins' original 32 variables were used in this study. The variable not included was a critierion score. Sixteen of the 31 variables were body-projection items; six involved moving or supporting the body weight against gravity; two were object-projection items; three were abdominal strength as measured by the sit-ups; and the remaining four were two squat-thrust items (same as the Burpee) and two pick-a-back (test involves carrying another individual on the back).

Nine effective factors were obtained for Models A and B and 10 for Model C. There were 16 effective factors for Model D. The results for five of the solutions are for all practical purposes identical. The derived independent cluster solution for Model C and the derived orthogonal solution for Model D differ to some extent but nevertheless show many similarities to the remaining five. The results for all seven solutions, therefore, will be presented and discussed as a group of solutions. The solution included in the appendix is the derived independent cluster solution for Model B.

Models A, B, C, and D

One of the factors is identified in the five similar solutions by all of the body-projection items of the jump type (variables 9, 15, 16, 22, and 28). Two other variables have their highest loadings on this factor and these are the two object-projection variables (items 10 and 27). Variables 2, 12, 23, 25, 30, and 31 also have small loadings on this factor. In contrast, the results for the remaining two solutions, the derived independent cluster solution for Model C and the derived orthogonal solution for Model D, suggest two factors: one associated with the jump items and one with the object-projection tests. The jump items, however, do not group themselves in precisely the same way for Model C as they do in the other solutions. Items 16 and 28 appear together as the jump factor, but item 9 (running broad jump) associates itself with the short runs and items 15 and 22 have no clear identification with a single factor having small loadings on two or more different factors. This factor (or factors) then accounts for five of the body-projection items and the two object-projection items in the Cousins data.

The body-projection items which might be described as short runs appear together on a factor in all seven solutions. These are variables 13, 21, and 23

(6-second run, 100-yd. dash, and 75-yd. dash). Variables 24, 25, and 30 also appear to a limited extent on this factor in most of the solutions as do variables 9, 15, and 20 in the orthogonal solution for Model C and variables 2 (2 is negative), 8, 9, and 22 in the derived independent cluster solution for Model C. Variable 24 will be discussed with this factor. It is a 150-yd. dash which might be categorized as a medium-length run and there is only one test item of this type. Item 24 has its highest loading on the dash factor in one of the solutions, a substantial loading although not the highest in a second, and its only loading, although small, in two others. In two solutions it appears with the jump factor previously described, and in the remaining two it has small loadings on two or more factors. Thus there appears to be no clear location for this test item.

The body-projection items that might be described as long runs are items 3, 18, 25, 30, and 31 (distances of more than 200 yards are covered). In six of the solutions, items 3, 18, 25, and 31 appear together with some of 9 and 22 in the orthogonal solutions for Models A and B. Item 31 (200-yd. shuttle) is not clearly associated with this factor, however, since it has, in general, loadings of about the same magnitude on the jump factor as well. In contrast, the results for the derived orthogonal solution for Model D suggest two factors. One is a factor specific to variable 3 (300-yd. shuttle), and variables 18 and 25 (250-yd. shuttle and 220-yd. dash) appear on the second factor. The remaining variable described as a long run (300-yd. run, item 30) appears on this factor in only one solution--the derived orthogonal for Model A. In one of the solutions it is associated with the jump factor, in two with the short runs, in two it has small loadings on two or more factors, and in the derived orthogonal solution for Model D it appears with the standing, hop, step and jump on a separate factor. This variable apparently involves a motor performance somewhat different from that of the other long-run tests.

The remaining two items of the body-projection type are the dodge run and the hurdle run (variables 12 and 26). These appear together on a separate factor in six of the seven solutions. Variable 30 appears on on this factor also to some extent. In the remaining solution, Model B, derived independent cluster, item 12 appears with item 20 and some of variable 26, although 26 also is associated with the sit-ups. These two tests appear to represent aspects of body projection quite distinct from that of the other items of this category.

The variables characterized as items in which the body weight is moved against gravity were item 2 (pull-ups), item 5 (push-ups), item 6 (squat jumps), item 14 (straddle chins), item 17 (dips), and item 20 (rope climb). The last item appears as a specific factor in five of the seven solutions, associates itself with the dodge run in one solution, and with items 2 and 17 in the seventh. Thus the rope climb apparently represents an ability somewhat distinct from the other test items of this type. Items 5, 6, and 17, along with item 29 (leg lifts) appear together on a separate factor in five of the seven solutions with variables 2 and 4 having small loadings as well. In the derived orthogonal solution for Model D, the results suggest two factors; one represented by items 5 and 17 and a second by items 6 and 29. In the remaining solution, items 5, 6, and 17 are grouped and variable 29 has no clear representation having small loadings on two factors. These four test items do involve lifting the body weight against gravity and their association is not surprising. Although variable 29 has most frequently been categorized as an abdominal strength item, a considerable portion of the body mass must be lifted against gravity. It should be noted that in these data, it does not associate itself with the sit-up items. The remaining variable in this category was item 14, the straddle chins. This item appears on the abdominal strength factor. It is possible that in the performance of this item, the lifting of the body mass is initiated by the abdominal muscles (possibly incorrectly so) thus explaining this finding.

The two remaining abdominal strength items, both sit-ups (variables 1 and 19), appear together on a factor in all of the solutions. Item 14 (straddle chins), as has already been mentioned, is associated with these items in six of the seven solutions. In the seventh, it appears as a specific factor.

Two of the miscellaneous test items were the pick-a-back (variables 7 and 11). In all of the solutions these appear together on a separate factor. These obviously represent a type of motor performance quite distinct from the remaining 29 variables.

The remaining two items in this matrix were squat thrusts (4 and 3), one performed for 60 seconds and one for 20 seconds. In five of the solutions these two variables appear together as a separate factor. However, variable 4 has, in general, much smaller loadings than variable 3. That there is some difference in these two items is substantiated by the fact that for the derived orthogonal solution for Model D, these two items appear as two specific factors, and in addition, item 4 appears with the abdominal strength items in two of the solutions.

Summary

The results obtained for the seven solutions of the Cousins' data were quite similar. The solutions for Models A and B (four in total) and the derived orthogonal solution for Model C were almost identical. The results for the derived independent cluster solution for Model C and the derived orthogonal solution for Model D differed in some respects but there was, nevertheless, considerable similarity in the seven solutions of the data.

The body-projection items were represented by four factors--the jump items clustering together, the short runs appearing together, the long runs appeared on one factor as did the dodge run and the hurdle run. The two items measuring object-projection appeared with the jump factor in all but two solutions. It is interesting to note that in the Brogden, Lubin, and Burke results, at least four variables of this type were included and the results in all solutions suggested that object-projection was separate from any other type of motor performance. This would suggest that the results obtained from the two "apparently discrepant" solutions might, in fact, more clearly represent this aspect of performance.

The test variables for moving the body weight against gravity were represented by two factors in all solutions with one exception. The rope climb item emerged as a specific factor in all but one of the solutions. It should be noted that this supports the results obtained with the Brogden, Lubin, and Burke data for the one solution which appeared to most clearly define this test item. The solution in which these test items were represented by three factors instead of two was the derived orthogonal solution for Model D in which the total number of factors extracted was considerably larger than for the remaining six solutions. The four variables grouped together in the six solutions were split into two clusters in this solution in which 16 factors were obtained.

Two of the test variables to measure abdominal strength appeared together in all solutions; whereas the leg lift was more clearly associated with lifting the body weight against gravity. The two pick-a-back items emerged as a factor as did the squat thrusts, although this pair of items were not as clearly defined as a separate factor.

Comparison With the Original Solution

A comparison with the original solution by Cousins must be made with some caution. Cousins' original data consisted of 32 variables. However, for some reason not clearly explained, his factor solution is given for only 26 variables. Thus there were five more variables included in this study than appeared in the original solution. Nevertheless, some comments can be made.

Cousins factored his matrix using Thurstone's multiple factor analysis, rotated graphically, and presents a four-factor solution. One of his factors is represented by 12 of the body-projection items and the two object-projection items. This puts together the jumps and the long and broken runs of the body-projection tests. A second rather broad factor groups the two pick-a-back tests as well as the short runs. His third factor is identified by items 5, 10, and 17 and the fourth consists largely of items 1 and 19--the two sit-up tests.

The results obtained in this study tend to suggest that the data should be represented by many more than four factors; probably by at least twice as many. The body-projection items appear to be grouped rather grossly in the Cousins' analysis in contrast to the clearly defined clusters obtained in this study. Cousins' second broad factor is also not verified in that the variables loading on that factor are represented by two smaller clusters in the analyses made in this study. The factor represented by the sit-up items is supported by the results of this study. The fourth factor obtained by Cousins groups the medicine ball put with the push-ups and dips and this exact factor is not supported by the results of this study. However, the push-ups and dips did not appear together as a separate factor in all solutions in this study and in most instances with two of the variables which Cousins did not include in his factor solution. Thus, in general, Cousins' two broad factors were not obtained in the solutions in this study whereas the two factors represented by smaller numbers of variables were obtained.

Cumbee Matrix

There were 21 variables in the original analysis of the data and all of these were included in the analyses completed in this study. There were three variables which were of the body-projection type and two of the object-projection type. There were five balance items--three involved balancing a stick and the remaining two involved balancing the body in some fashion. There were three items that involved hand-eye coordination of some nature. Two variables were tests of the speed of moving the arms and hands. Three of the items were included to measure some aspect of rhythm or tempo. There were three miscellaneous tests--the Burpee, and two parts of the Johnson Motor Educability Battery.

When the data were factored for this study, six effective factors were obtained for Models A and B, five for Model C, and eight for Model D. In presenting the results for discussion, four solutions--derived orthogonal and derived independent cluster for Models A and B--will be commented on as a group. Then the two solutions obtained for Model C will be discussed. Finally the derived orthogonal solution for Model D will be commented on. The derived orthogonal solution for Model B is given in the appendix.

Models A and B

The same general factor structure is apparent for all four solutions. One of the factors is identified by three of the balance tests--those involving balancing a stick. For the orthogonal solutions, variables 4, 5, 15, 16, 17, and 18 appear on this factor with small loadings. A second factor is identified in the two solutions for Model A by the two remaining balance tests--those involving body balance (variables 4 and 5)--as well as by the two Johnson sub-test items (variables 19 and 20). Variables 8 and 18 appear on this factor to a limited degree. For both solutions for Model B, variables 4, 19, and 20 appear on this factor, however, variable 5 (static balance) does not. Variable 5 is not accounted for at all clearly in the solutions for Model B. The appearance of the Johnson sub-test items is not at all surprising since the performance on these sub-tests requires balance of the total body while in motion thus this test would have elements similar to variable 4 (dynamic balance).

A third factor is identified by the three tempo variables (items 6, 7, and 8) in three of the four solutions. For the derived independent cluster solution for Model B, variable 8 is not represented on this factor.

A fourth factor is identified by two of the test items in all four solutions--crosses and vertical lines and nose and ear (variables 9 and 10). Variables 8 and 17 have negative loadings on this factor as well.

A fifth factor is identified by stick placing and block tapping (variables 11 and 12). Variable 5 has a small loading on this factor in one solution and variable 19 has a negative loading on this factor in the derived independent cluster solution for Model B.

The remaining factor is identified, generally, by those items classified as body-projection and object-projection as well as the ball catch and the Burpee. The results are not identical for the four solutions, however. The short potato race (variable 14), the basketball throw (variable 16), the ball catch (variable 17), and the jump and reach (variable 21) are the only tests that appear on this factor in all of the four solutions. Variables 13 and 15 appear on this factor in some but not all. In addition, variables 18 and 19 appear on this factor to some extent and variable 8 has a negative loading on this factor in the derived independent cluster solution for Model A.

To summarize, the general factor structure appears to be very similar for these four solutions. The six factors, however, do not account for all of the variables included in the matrix. The two solutions for Model B leave at least four of the variables unidentified with the factor structure. The solutions for Model A account for more of the variables and if this is a legitimate criterion the clearest explanation of the data appears to be given by either of the two solutions for Model A with some slightly greater clarity in the derived orthogonal solution.

Model C

Five factors were extracted for Model C. This is a somewhat unexpected finding since, for many of the motor performance matrices, more factors have been extracted for Model C than for Models A and B. Four of the factors obtained in the solutions for Models A and B are reproduced in these two solutions--the two factors commented on for the balance plus the Johnson items appear here also as do the two factors associated with hand-eye coordination and speed of movement, although variable 12 does not appear with variable 11 in this analysis. Finally, the factor represented by the body- and object-projection tests plus the ball catch is obtained. One factor less was extracted and the tempo items are not accounted for in this analysis. The two solutions for Model C appear to be somewhat less satisfactory than the solutions for Models A and B in which six factors were obtained.

Model D

Eight factors were obtained in this analysis. Five of these factors are essentially the same as those found in the solutions for Models A and B--the two balance factors, the hand-eye coordination factor, the speed of arm movement factor, and the factor identified by the body- and object-projection tests as well as the ball catch.

The variables representing the rhythm or tempo aspects are represented by two factors in this analysis. Variable 8 (tempo, total body) was associated with the other two tempo items in three of the four previously discussed solutions but not in the fourth. In this analysis, variable 8 is specific to a factor. There is no obvious representation of these three test items.

The eighth factor in this analysis consists of variables 17 and 18 (ball catch and ball strike). This is an interesting finding in that in none of the six solutions previously commented on was variable 18 accounted for. The one test item not accounted for in this analysis was the Burpee test.

Summary

The two solutions for Model C seem to give a much less satisfactory representation of the data than the remaining five solutions. The two solutions for Model A and the derived orthogonal solution for Model D leave fewer test items unaccounted for in the factor structure, and all of the factors obtained are logical ones. The eight-factor solution suggests two smaller clusters for the tempo variables and variable 18 (ball strike)--unaccounted for in all of the remaining solutions--appears with variable 17 as a factor.

Comparison With the Original Solution

Cumbee used the multiple-group method of factoring and rotated the initial solution to a primary solution according to procedures given by Harris and Schmid. Eight factors were obtained but one of these was extracted to facilitate the rotation of one of the first seven factors and was not discussed or named--thus the solution presented actually consisted of seven identifiable factors. The seven factors were: a balance factor identified by variables 1, 2, and 3; a tempo factor identified by variables 6, 7, and 8; a factor named two-handed agility identified by variables 9 and 10; a factor named speed of change of direction of arms and hands identified by variables 11 and 12; a factor called body balance identified by variables 4, 5, 19 and 20; a factor which was not named, identified by variables 14, 16, and 17; and the seventh factor was a doublet, not named, identified by variables 17 and 18.

Three of the factors in the Cumbee analysis are clearly supported by the analyses in this study--the factor identified by variables 1, 2, and 3; that identified by variables 9 and 10; and finally that identified by variables 11 and 12. The factor called body balance by Cumbee was also obtained in the analyses in this study with variables 4 and 5 more clearly associated with this factor in all of the solutions in this study than in the original. Neither variable 4 nor 5 is as clearly accounted for in the original analysis.

The tempo factor obtained in the original analysis is also substantiated to some extent in this study. A similar factor is obtained in three of the seven solutions, no tempo factor is obtained for Model C, however. The results for Model D suggest at least two factors for these three test items.

One of the Cumbee factors was identified by variables 17 and 18 and is reproduced in this study in the derived orthogonal solution for Model D. It does not appear in the remaining six. The last factor obtained by Cumbee was identified by variables 14, 16, and 17 and a factor similar to this appears in all of the analyses made of the data in this study. More test items are associated with this factor in this study than in the original analysis.

In general, the results obtained in the analyses in this study support the factors obtained in the original study. Some differences were apparent.

Fleishman-Speed Matrix

There were 30 variables in the original data and all of these were included in the analyses made in this study. Six of these were tests designed to measure flexibility--three for extent flexibility and three for dynamic flexibility. There were 12 tests of balance--eight involved what has been termed status balance, two involved balancing objects, and the remaining two were body balance tests. Six of the tests were designed to measure the speed of limb movement--three for the arms and three for the legs. There were three tests which the authors labeled as speed of change of direction--these we have been referring to as tests of body-projection. The last three tests were called coordination items and included a soccer dribble, and two tests constructed specifically for the study.

When these data were factored for this study, nine effective factors were obtained in the solutions for Models A and B, 10 were obtained for Model C, and 15 were obtained for Model D. All of these solutions will be presented and discussed as a group of solutions since the general factor structure is much the same over all seven solutions except for the fact that a number of singlets and doublets are obtained for Model D. The solution included in the appendix is the derived independent cluster solution for Model B.

Models A, B, C, and D

One factor is identified by the three body-projection tests (variables 13, 14, and 15), two of the tests categorized as "coordination" items (16 and 17), and variable 8--arm circling. Variable 18--soccer dribble--is essentially on this factor although the loadings are substantial in only two of the solutions. This test appears as a specific factor in Model D and is clearly not well accounted for. Variable 7 appears to a limited extent on this factor in the orthogonal solutions and variable 11 has a small negative loading on this factor in the derived independent cluster solutions for Model C.

Two of the balance items (variables 20 and 24)--1-ft. lengthwise balance, eyes closed and 2-ft. crosswise balance, eyes closed--have their highest loadings on one factor in all solutions. Variable 23--2-ft. crosswise balance, eyes.open, has its highest loading here in six of the solutions but appears elsewhere in the derived independent cluster solution for Model C. In that solution, variable 23 appears with variables 19 and 21--all tests of balance with the eyes open. Several more of the balance items (21, 22, and 27) also appear on this factor to some extent in some of the solutions.

Another of the factors is identified by two more of the balance items (variables 19 and 21)--both tests of crosswise balance, eyes open. Variables 28 and 29 also appear on this factor in the solutions for Models A and B and in the derived independent cluster solution for Model C, variables 23 and 24 appear on this factor. Variables 23, 28, and 29 also appear on this factor as do few others to a limited extent.

Three of the balance tests (variables 22, 25, and 26) identify the next factor in the four solutions for Models A and B. One of these tests is a crosswise balance, eyes closed; the next is a lengthwise balance, eyes open; and the last is the lengthwise balance, eyes closed. For Models C and D, two factors are obtained. One in which variables 20, 22, and 25 are associated and a second in which 25 and 26 are associated in two of the solutions with 26 a specific in the derived orthogonal solution for Model C. Variable 28 has small loadings on this factor in two of these solutions.

In Model D, three of the balance tests--variables 27, 28, and 29--appear as specific factors.

Variables 4, 5, 6, and 9 identify the next factor and include three of the tests for dynamic flexibility as well as one of the speed of arm movement items. It should be noted that variable 4--squat, twist, and touch--appears with some of variable 24 on another factor in the derived independent cluster solution for Model C and variable 19 has a small negative loading also. Variable 7 appears to some extent on this factor; another of the speed of arm movement test items. Variable 10, a speed of leg movement test, appears on this factor in all four of the orthogonal solutions. In addition, there are a few other tests loading on this factor and this varies for the different solutions.

In all seven of the solutions, a bipolar factor is obtained for the test items 3 and 7--twist and touch and plate tapping. Variable 8, arm circling, appears with 7 in some of the solutions to a limited degree.

A doublet, represented by test items 11 and 30--2-ft. tapping and ball balance--was obtained in six of the solutions. Variable 22 has a small negative loading in the derived independent cluster solutions for Models A and B. No such factor appears in the derived independent cluster solution for Model C, however, variable 11 also appears as a singlet in Model D.

Variables 1 and 2--two of the extent flexibility tests--identify one factor in all seven of the solutions. Variable 29 appears on this factor in the two solutions for Model C.

The last factor is identified by variables 10 and 12--two of the speed leg movement measures. Variable 27 (rail walking) is associated with this factor in six of the solutions in varying amounts. Variables 2, 6, and 17 also appear to a limited extent.

Summary

Seven factors, represented by at least two test items, appear in all seven of the solutions. Two of these are associated with the balance tests; one with the body-projection and coordination items; one with two of the extent flexibility tests; one with the three dynamic flexibility tests plus the block transfer; one with two of the speed of leg movement tests; and the last is a bipolar for variables 3 and 7. The doublet, pairing variables 11 and 30, is obtained in all of the solutions except the derived independent cluster solution for Model C. An eighth factor associated with some of the balance tests is obtained in the four solutions for Models A and B but these items are represented by two factors in the solutions for Models C and D. These two factors, plus additional singlets and doublets in the solutions for Models C and D account for the larger number of factors extracted in the latter set.

Comparison With the Original Solution

Fleishman and his associates obtained six factors in their analysis of these data. Three of the factors are reproduced in the solutions obtained in this study. Two of the factors obtained by the original analysis are interesting in that they each represent a pair of the factors obtained in all seven of the solutions in this study. Thus there appears to have been a coalescing of four of the factors obtained in these analyses into two factors in the original solution. Fleishman's sixth factor is not reproduced in this study. It includes six test items; variables 11 and 30 which appear as a separate factor in most of the solutions obtained in this study but the remaining items are grouped differently than in any of the results obtained in the analyses made for this study.

Fleishman-Strength Matrix

There were 41 test items in the original study of which 11 were eliminated in the analyses made in this study. The variables eliminated were anthropometric tests and a number of indices. The remaining 30 tests consisted of 10 items in which the body weight was moved or held against gravity, five tests of body-projection, three tests of object-projection, four tests of the abdominal strength type as in the sit-ups, etc., six tests measuring strength by an instrument, and two miscellaneous tests--the squat thrusts (Burpee) and a reverse sit-ups or back lift item.

When these data were factored by the various methods used in this study, seven effective factors were obtained in the solutions for Models A and B, nine for Model C, and 13 for Model D. The results for Models A and B will be presented and discussed first, followed by the results for the two solutions for Model C, and finally the results obtained for Model D. The solution given in the appendix is the derived independent cluster solution for Model B.

Models A and B

One factor is identified in all four solutions by seven of the 10 items (13, 14, 16, 20, 22, 24, and 30) to measure moving or holding the body weight against gravity. Two more of these (item 2, push-ups in 15 seconds and item 23, hold half push-up) appear on this factor in three of the four solutions but in the derived independent cluster solution for Model C these two variables along with variable 6 (squat thrusts or Burpee) form a separate factor. This is not an unusual grouping since in the performance of all three the body weight is supported or moved with the arms and body in exactly the same relationship. The remaining variable in this category--deep knee bends--appears on this factor in all four solutions but its identification is not as clear with this factor as for the previous items. It has its highest loading on this factor in one solution only, and is low on this factor and at least one other in the three other solutions.

A second factor is clearly identified by the five items for body-projection. There are two other tests which have their highest loadings on this factor also. These are the softball throw (item 29, object-projection) and the sit-ups (item 5, abdominal strength). The sit-ups also appears to some extent on at least one other factor, however.

Three of the four abdominal strength tests appear on one factor. These are the leg lifts, leg raiser, and hold half sit-up. It is interesting to note that the fourth abdominal item--the sit-ups appears to involve a performance somewhat different from that of the other three tests. The three which are grouped together all involve primarily the use of the thigh flexors either in active lifting of the legs or in holding the legs or the upper trunk in a stationary position against the pull of gravity. The sit-up item is an active lifting of the upper trunk and apparently involves the upper trunk muscles more than the thigh flexors.

Two factors are identified by the dynamometric strength measures. Items 8, 10, and 12 (hand grip, arm pull, and trunk pull) are grouped on one factor along with one of the object-projection items--the medicine ball put standing. Items 7, 9, and 11 (pull weights--arms; push weights--arms; and push weights--feet) are grouped on the second factor along with another of the object-projection items--the medicine ball put sitting. These two factors are somewhat unusual. The medicine ball put while standing is performed with considerable action of the trunk and pelvis and the ball is held in one hand. Thus its association with the arm and trunk pull is quite defensible since the arm and trunk pull involve considerable action of the upper trunk. The medicine ball put in a sitting position is performed in quite a different fashion. No body action is used and the ball is held in two hands. Possibly what this item and the three push and pull weight tests have in common is the use of the extremeties exclusively, either arms or legs. Variable 4 (deep knee bends) appears on this factor also. Note that the extremeties are primarily involved in this test also.

One factor in all of the solutions is almost entirely specific to variable 3 (reverse sit-ups). Variable 11 appears on this factor to a small degree in one solution and variables 5 and 28 have small negative loadings on this factor in three and four of the solutions, respectively.

The last factor obtained is different for Models A and B. In Model A, variable 6 (squat thrusts) with some of 2 and 23 (push-ups in 15 seconds and hold half push-up) is bipolar with variable 4. In the derived orthogonal solution for Model B however, there is no bipolarity. In the derived independent cluster solution for Model B, the same three variables (2, 6, and 23) all have their highest loadings on this factor. The logic of this grouping has already been commented on.

Model C

Nine factors were obtained for Model C thus there were two more than for the solutions for Models A and B. One of these factors is essentially the same as that obtained in Models A and B--the body-projection tests with the softball throw. Variable 5, the sit-ups, loads on this factor but not to the same extent as in the previous solutions. It is less clearly associated with this factor in these two solutions, although it is not clearly identified with any other factor either.

The moving or holding body weight items appear on three factors in this solution rather than on one or two as in Models A and B. The factor grouping variable 2, 6, and 23 appears in both of these solutions with variable 30 added (push-ups to the limit); with 6, however, loading on two factors, its highest on this factor in the orthogonal solution and its highest on a different factor in the derived independent cluster solution.

The remaining items in this category which appeared on a single factor in Models A and B, group themselves into two factors in the two solutions for Model C. One of these is identified by the test items in which the body weight is pulled against gravity as in the chins and rope climb and the second involves the tests in which the body weight is pushed against gravity--the dips. However, this latter factor differs in the two solutions to some extent. In the orthogonal solution items 9 and 11 appear with dip tests and in the derived independent cluster solution, the deep knee bends and the rope climb appear on this factor.

One factor in these solutions is identified by variables 7 and 9 with some of variable 27. This is similar to one of the factors in Models A and B but not entirely so. Variable 11, for example, is not identified with this factor in these two solutions in contrast to Models A and B. Similarly the second factor involving the dynamometric strength tests is similar but not identical with the factor obtained in Models A and B. Items 8 and 10 along with 25 appear on this factor as does variable 12 in the orthogonal solution. However, variable 12 is also specific to a factor (.37) in the orthogonal solution and appears on a different factor in the derived independent cluster solution along with variables 1, 17, and 27.

A factor in which variables 1, 18, and 26 (with some of 5) is obtained in the orthogonal solution here is similar to that found for Models A and B. However, variable 20 has a substantial loading on this factor as well. For Model C, however, variables 18, 20, and 26 have their highest loadings here and 1 and 5 are represented to some extent. There is no explanation for the bent arm hand (item 20) being associated with this factor.

Model D

Fifteen effective factors were obtained for this solution. The moving or holding body weight items form two factors--one is similar to the factor obtained for the majority of these tests in the solutions for Models A and B. The second is similar to the factor obtained in Model C which groups variables 2, 28, and 30, although variable 6 does not appear on this factor in Model D, but rather appears as a specific. One factor is the same as that obtained in all of the previous solutions and groups the body-projection items, the softball throw, and the sit-ups appear here to some extent. The sit-ups also appears as a specific factor with a small loading. Another factor is identical with that obtained in Model C, with variables 7 and 9 grouped together and 27 appearing to some extent. Variable 27 also appears as a specific. Another factor is the same as that obtained in five of the six solutions in which items 8, 10, 12, and 25 are grouped. Additional tests load on this factor in this solution to some extent.

Another factor in this solution groups items 1 and 26 with some of 20. In contrast to the results obtained for the previously discussed solutions, variable 18 does not appear on this factor but is a specific factor.

The last factor is more or less specific to variable 4 (deep knee bends) although items 14 and 16 appear to some extent. In addition, there is a factor specific to variable 11 to the extent of .34.

Thus for Model D there are six factors similar to factors found in either the solutions for Models A and B or Model C. There are, in addition, seven factors, specific to a single test item (including in this the factor more or less specific to variable 4).

Summary

Nine of the 10 tests involving moving or supporting of the body weight against gravity group themselves into a single factor in two solutions for Model A, although items 2 and 28 also appear with variable 6 on a separate factor. This latter factor becomes more clearly differentiated for Models B, C, and D. In addition, the two dip tests separate as a factor from the remaining tests in this category in the two solutions for Model C. The last variable, deep knee bends, is not clearly associated with any factor. It is interesting to note that it appears as a specific in Model D.

The body-projection items along with the softball throw and less clearly the sit-ups group themselves on a single factor in all of the solutions.

Three of the four abdominal tests are grouped in five of the solutions.

The six tests of dynamometric strength are, in general, represented by two factors but these two factors are not identical over the set of solutions.

Of the three tests for object-projection, the softball throw has already been commented on, and the two medicine ball puts are clearly not associated, appearing on different factors.

Comparison With the Original Analysis

The data were factored in the original analysis using the centroid method and the factors were rotated by the Kaiser Varimax analytical solution. Seven factors were obtained. As pointed out in the opening paragraph of this section, 11 of Fleishman's original 41 variables were eliminated from the analyses in this study. Two of the seven factors obtained in the original solution were associated with the 11 variables omitted from the study. Therefore, the remaining five factors will be commented on in relation to the results obtained in this study.

One of Fleishman's factors includes all of the moving or supporting body weight items except the deep knee bends. The results for Model A are similar to this, however, for Models B, C, and D, three of these test items begin to group themselves into a second factor, and in the results for Model C, a third factor is obtained. Thus the results obtained in this study support Fleishman's single factor in only two of the solutions obtained, whereas a different structure is suggested in the other five.

A second factor obtained by Fleishman groups the body-projection items and the softball throw with the sit-ups appearing here to some extent. This factor is supported in the results obtained in this study.

A third factor obtained in the original analysis groups three of the abdominal tests and this factor is also obtained in Models A and B but the factor is not precisely the same in the solutions for Models C and D.

The fourth factor groups variables 7, 9, and 11 and this factor is obtained in the solutions for Models A and B in this study but not in Models C and D. In the latter two, variable 11 is not associated with 7 and 9.

The last factor groups items 8 (some of 9), 10, 12, 25, 27, and some of 29. This factor is almost identical with the factors obtained in the derived orthogonal solutions for Models A, B, C, and D. However, in all instences the derived independent cluster solutions are similar but not identical.

In general, four of Fleishman's five obtained factors are supported to a considerable extent in the results of this study. However, the fifth factor is supported only to a limited degree, and the results of this study tend to suggest a somewhat different organization for the test items grouped in this factor in the Fleishman study. The Fleishman analysis does not account satisfactorily for variables 3 and 4, and variable 5 is quite low on two factors. It should be noted that all three of these tests appear as specifics in the solution for Model D.

McCraw Matrix

There were 30 variables in the original study of which only 15 were retained for the analyses made for this report. Six of the variables dropped were gain scores for some of the test items and could not be included. The remaining items dropped were anthropometric variables and various indices. The 15 tests that were used for this study included four items of the body-projection type, four items that involved object-projection, two involved moving the body weight against gravity, one was the sit-ups, two were squat thrust tests (Burpee), one was a rhythm test, and the last a tangle test.

When the data were factored for this study, three effective factors were obtained for Models A and B and these will be presented and discussed as a group of solutions. For Model C only two factors were obtained and these two solutions will be commented on next. Finally for Model D, six effective factors were obtained and the results for this solution will be discussed last. The solution given in the appendix is the derived orthogonal solution for Model D.

Models A and B

One of the factors obtained is identified by the four tests of body-projection and the four tests of object-projection. The sit-ups test also appears on this factor but appears to an almost equal extent on another factor as well.

A second factor is identified by the two tests for moving the body weight against gravity (items 6 and 7) and the two squat thrust tests (items 9 and 10). The sit-up test appears on this factor as well as the first factor described above. The standing broad jump (item 3) has rather substantial loadings on this factor as well as the previous factor.

The third factor is identified by the tangle and rhythm tests (variables 14 and 15).

Model C

The derived orthogonal solution for Model C yields two factors which are similar to the first two obtained for Models A and B. In this solution variables 1, 2, and 5 have small loadings on the second factor but did not in the solutions for Models A and B. Variable 14 has a small loading on the second factor and variable 15 has no sizable loading on either factor.

The derived independent cluster solution differs to some extent. On the first factor, variables 1, 2, 4, 11, 12, and 13 appear as they do in all of the previous solutions. However, variable 5 does not appear on this factor at all but has a small loading on the second factor. Variables 9 and 10 have moderate negative loadings on the first factor. The second factor is almost identical with the factor obtained in the derived orthogonal solution except that variable 14 has a higher loading on this factor in this solution. Variable 15 again has no sizable loading on either factor.

Model D

Six effective factors were obtained for the solution although the sixth is a specific to variable 8 and the loading is small, .31. Variable 8 also appears to some extent on two other factors; similar to the results obtained in the previously discussed solutions.

Another of the factors obtained in this solution is identical with one of the three factors obtained in Models A and B where variable 14 and 15 appear as a doublet. It will be recalled that this factor does not appear in the solutions for Model C. The remaining four factors contain the test items found on the two factors in the previous six solutions.

One of the four remaining factors is identical to one of the factors obtained in the derived independent cluster solution for Model C. Variables 1, 2, 3, 4, 11, 12, and 13 appear on this factor. Note that variable 5 does not appear here although it did in the solutions for Models A and B. In the solution for Model D, variable 5 appears on a separate factor along with variable 1 and some of variables 2 and 3. Thus of the four body-projection tests, the two tests involving a run are now separated from the two jumps which still appear with the object-projection variables.

Another factor obtained in the solution for Model D is identified by variables 9 and 10--the two squat thrust tests. The last factor is identified by variables 1, 3, 6, and 7 and the sit-ups (item 8) appears here to a limited degree as well. Thus for Model D, the two squat thrust items separate off as a factor in contrast to the results obtained for the six solutions already presented as do variables 1 and 5--the two body-projection tests involving a run. It should be noted, however, that variable 1 has moderate loadings on three factors, and this result has not occurred previously. The appearance of variable 3 on two factors occurred in five of the solutions previously reported.

Summary

The two-factor solution obtained for Model C would seem to be less satisfactory than either the three-factor or six-factor solutions obtained for Models A, B, and D. The doublet of variables 14 and 15 appears in the latter solutions and neither of these two variables is clearly identified in the solutions for Model C. The separation of the two squat thrust tests into a separate factor in Model D as well as the splitting off of variable 5 with some of variable 1 suggest the possibility that more than three factors are necessary to give the clearest picture of these 15 test items. Attention should also be called to the fact that the sit-up test which has no clear identification in any of the six solutions for Models A, B, and C appears as a specific in Model D, thus it is conceivable that as many as six factors are needed.

Comparison With the Original Solution

Any comparison with the original solution will be extremely difficult to make since only 15 of the original test items were retained in the analyses made in this study. McCraw used Thurstone's multiple factor analysis and Thurstone's single-plane method of rotation to derive his solution. The original rotated solution was looked at to identify the structure for the 15 variables used in this study. It would appear that five or six factors are associated with these tests. One of these includes two of the body-projection tests and one of the object-projection tests. This factor is not reproduced in any of the analyses in this study although these variables do appear on a factor in this study along with a number of other test items.

Only one of the factors in the McCraw analysis is reproduced in the results obtained for this study. Variables 6, 7, 8, 9, and 10 appear to identify one of McCraw's factors and this factor was obtained in six of the solutions presented in this study. None of the other factors are at all similar to any obtained in this study. However, these comments should be interpreted with considerable caution since the number of variables in the original study is considerably greater than the number used in this study.

Phillips Matrix

There are 26 variables in the original study and two of these, which were indices of some sort, were not used in the analyses made for this investigation. Of the remaining 24 variables, six could be categorized as body-projection tests, one was a test of object-projection, there were two items for moving the body weight against gravity, there were five tests of abdominal strength, there were four tests using an instrument such as a dynamometer, there were two tests that have been designated as motor ability batteries, and there were four miscellaneous items--one balance, the Burpee, the Brouha (step test), and the Spirometer (lung capacity).

When these data were factored by the methods used in this study, six effective factors were obtained for the solutions for Models A and B, none were obtained for Model C, and 11 for Model D. The four solutions for Models A and B will be discussed as a group of solutions, followed by a discussion of the results obtained for Model C, and the results for Model D will be presented last. The solution given in the appendix is the derived orthogonal solution for Model D.

Models A and B

One factor is identified by all six of the body projection tests (1, 2, 3, 3, 13, and 15) in three of the four solutions, however, the 20-yd. hop and agility run (items 2 and 3) do not appear on this factor in the derived independent cluster solution for Model B. Both motor ability tests (items 4 and 9) appear on this factor in all four solutions. The balance test (item 6) also has its highest loading on this factor in three of the four solutions and in the fourth it loads on this factor to some extent but also has a small loading on a second factor. The object-projection test (variable 14) appears on this factor in three of the four solutions, having its highest loading on this factor in two and a small loading in the third. Variable 23 appears on this factor in some but not all of the solutions with a small loading as does Variable 10.

A second factor is identified by those tests which measure strength by an instrument (variables 18, 19, 20, and 21). In addition, the spirometer test (item 24) appears on this factor, and variable 14 (basketball throw) has a small loading in the two orthogonal solutions.

The next two factors are identified by the five tests designed to measure some aspect of the performance of the abdominal muscles. There were five tests in this category. Three of these were some measure of the sit-ups (variables 11, 12, and 16) and these cluster together on one of the factors. Variable 5 (V-sit) also appears on this in three of the four solutions. Variables 5 and 7 (half sit hold and the V-sit) identify the second factor here. Variable 4 (Humiston Motor Ability) loads on this latter factor to some extent as well.

Another factor is identified by the two tests for moving the body weight against gravity (variables 22 and 23). Variable 17 (Brouha) has its highest loading on this factor in the derived orthogonal solution for Model A. Both variables 6 and 24 (negative loading in the independent cluster solution) appear on this factor to a limited extent in the solutions for Model A.

The last factor is not identified by the same test items in all four solutions. Two test items appear here consistently--variables 10 and 17--the Burpee and the Brouha. Both tests have their highest loadings here in two of the four solutions, a sizable loading in the third, and a small, but the only loading for these test items in the fourth. However, for the derived orthogonal solution for Model A, variables 8 and 14 have their highest loadings on this factor and variables 1, 2, 3, and 15 have substantial loadings. Similarly for the derived independent cluster solution for Model B, variables 2, 3, 8, and 14 have their highest loadings on this factor and variable 15 appears to a substantial extent as well. Two variables--9 and 13--have small negative loadings on this factor in the derived independent cluster solution for Model A. This factor in the derived orthogonal solution for Model B has no loadings for any test item as large as .40. As has already been pointed out, however, variables 10 and 17 have their only loadings on this factor and variables 12 and 22 appear to some extent.

Model C

Two factors in the solutions here are for all practical purposes identical with the two factors obtained in the previously discussed solutions which are identified by the five tests of abdominal strength.

The four tests of dynamometric strength which identified a single factor in the solutions for Models A and B identify two factors in the results for Model C. One of these is identified by the two grip tests (items 18 and 19) with some of 20 in the orthogonal solution and the second by the tests for the back and legs (variables 20 and 21) with some of 18 and 24 in the orthogonal solution.

The body-projection tests which were grouped on a factor with the motor ability tests, the balance item, and others have a somewhat different representation in these two solutions. For the derived orthogonal solution, a factor is obtained which is quite similar to that obtained for Models A and B, except for variable 8 (side step). This item separates as a factor along with variable 1 (obstacle race). For the derived independent cluster solution, variables 1 and 8 appear together as above with some of variable 3 (agility run). However, the remaining tests are grouped on two other factors. Variables 4, 6, and 9 appear together, with some of variable 10; and variable 13 (jump and reach) appears on another factor along with some of variables 2 and 9. Variables 2 and 3 have their highest loadings with the two variables that measure the ability to move the body weight against gravity.

Finally, a factor is represented by variables 10, 14, and 15 with variables 2 and 3 having substantial loadings here as well in the derived orthogonal solution. The ninth factor in the derived orthogonal solution is specific to variable 14 (loading of .38).

Model D

Five of the factors obtained for these solutions are essentially the same as five of the factors just described. Two of these are identified by the dynamometric tests, two by the abdominal strength tests, and one by the two tests for moving the body weight against gravity.

Three of the factors in this solution are specific to a single test item--variable 4, variable 13, and variable 17, each identifying one of these. Of the remaining three factors, one is similar to the factor obtained in most of the solutions just discussed and includes the body-projection tests, the object-projection test, and the two motor ability items. The same factor which pairs variables 1 and 8 obtained in the two solutions for Model C also appears here. In addition, a factor similar to that obtained in the derived independent cluster solution for Model C is obtained: this factor is identified by variables 6 and 9; variable 4 does not appear here, however, as it did in Model C.

Summary

The general factor structure over the seven solutions shows a good bit of similarity with the additional factors in C and D obtained from a breaking up of larger clusters of variables into smaller clusters as well as some singlets in Model D. This breaking up occurs for the dynamometric measures and for the body- and object-projection measures. This similarity holds except for the sixth factor obtained in the four solutions for Models A and B. Actually this sixth factor differs considerably over these four solutions; something resembling it is obtained in Model C, but no such factor appears in Model D.

Comparison With the Original Analysis

Four factors were obtained in the original analysis when the data were factored and a rotated centroid solution presented. One of these factors was identified as general strength with variables 14, 15, 18, 19, 20, 21, and 24 appearing on the factor. A factor similar to this was obtained in the solutions for Models A and B although it must be noted that the factor is more clearly associated with the four dynamometric strength tests and does not include variables 14 and 15. For the solutions for Models C and D, however, these four variables identify two factors--one associated with the two grip tests and one associated with the back and leg tests.

Another of the factors in the Phillips' solution was named abdominal strength and was identified primarily by the five abdominal strength tests. This factor was not reproduced in any of the solutions presented in this study. In contrast to the single factor obtained by Phillips, these five test items appear on two factors--one of which is represented by the sit-up tests as differentiated from the V-sit and half-sit hold.

The factor identified by Phillips as Speed is not reproduced in this study. Two factors represent these variables in the solutions for Models A and B and at least three factors in Models C and D. For the latter a number of the variables clustered on this factor in the Phillips' solution appear as singlets.

UW - Balance Matrix

No analysis of this complete set of 31 variables has been previously reported in the literature. There were six balance items; four involved balancing the body and two, balancing objects. There were eight object-projection tests and five body-projection tests. Fourteen of the test items were measures of kinesthesis. Four of these were designed to measure awareness of body position, three to measure awareness of force exerted on an instrument, four to measure awareness of force in projecting an object, and three to measure awareness of force in projecting the body. These were not all completely different tests since wherever it was possible the particular test was performed both with the eyes open and the eyes closed. For example, the four body balance items were actually two tests performed both with the eyes closed and the eyes open.

When these data were factored by the procedures used in this study, nine effective factors were obtained in the solutions for Models A and B, 11 for

Model C, and 16 for Model D. The solutions for Models A and B will be discussed first, followed by the results for Model C, and finally those for Model D. The solution given in the appendix is the derived independent cluster solution for Model B.

Models A and B

One of the factors is identified by the four tests of body balance (variables 1, 2, 3, and 4) in which the body is balanced on a stick crosswise and lengthwise both with eyes opened and eyes closed. Variable 30 (foot bounce) has substantial loadings on this factor also and this is not an unexpected finding since balance is involved in the performance of the foot bounce. Variable 25 has a small, negative loading on this factor in all of the solutions. Variable 24 has a small, positive loading on this factor in three of the four solutions; not in the independent cluster solution for Model B.

Of the six object-projection tests, variables 7, 11, and 12 (overarm throw, eyes open; basketball throw, eyes open; basketball throw, eyes closed) appear on one factor in all four solutions. Variable 8 (overarm throw, eyes closed) appears on this factor in three of the four but also appears with variable 23 in all four solutions. Variable 9 (tennis serve) is on this factor in two solutions but also appears with the body-projection tests in all four solutions. Its location is, therefore, not clear. In addition, variables 1 and 17 have small negative loadings on this factor.

Four of the five body-projection tests (variables 27, 28, 29, and 30) appear on one factor as does the fifth (item 31) in the two derived orthogonal solutions. As has already been pointed out, variable 9 appears on this factor also, and variable 12 has small loadings in the two orthogonal solutions.

Thus, in general, each of the above categories of test items, with the exception of the two ball balance tests (items 5 and 6), appear together on a single factor in these four solutions. The exceptions have been noted. However,

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for the remaining variables, which have been classified as kinesthetic, the structure is far less clear. For the three variables designed to measure the awareness of force exerted against a dynamometer, variables 17 and 18 (push and pull) appear together on one factor in all four solutions and variable 2 has a small negative loading.

Variable 19 (knee flexion) appears on a doublet in three of the four solutions; with variable 15 (lower arm raise) in the derived orthogonal solution for Model A and with variable 28 (50-yd. dash) in the two derived independent cluster solutions. There is no explanation for the latter finding. Variable 19 with its various associated variables is bipolar with variables 10 and 17 for three of the solutions (not the derived independent cluster solution for Model B) although variables 10 and 17 do not appear consistently in the three solutions.

The four position items are variables 13, 14, 15, and 16. Varibles 13 and 14 cluster together to form a factor in three of the four solutions. In the derived orthogonal solution for Model B, variable 13 is bipolar with a cluster of variables grouping 1, 3, 6, and 20. Variable 14 is with 24 and bipolar with a cluster made up of 9, 22, and 31. This latter arrangement of variables also occurs in all of the other solutions. Variable 15 appears as a singlet in three of the four solutions and as a doublet with 19 (as already commented on) in the fourth and in all four solutions is bipolar with variables 10, 25, and 26. Variable 16 appears with variables 5, 6, and in some solutions with 9, 26, and 31 but is also bipolar principally with variable 21. In addition, for Model C, variable 16 appears also as a singlet which is bipolar with variable 20.

There is no grouping of the tests to measure awareness of force in projecting the body. Variable 20 is with 6 and 17 as well as others and is to some extent bipolar. Variable 21 is a singlet and bipolar. Variable 21 is a singlet and bipolar with a cluster of variables. Variable 22 appears with variable 31 and is bipolar with a doublet made up of 14 and 24.

The four force-awareness in projecting objects tests are 23, 24, 25, and 26. Variable 23 is with variable 8 (overarm throw, eyes closed) as a doublet. Variable 14 appears with variable 14 as a doublet and is bipolar with variables 22 and 31. Variables 25 and 26 appear together with other variables to some extent but the doublet is bipolar with variable 15 in three of the solutions and variable 21 in the fourth.

Model C

Only four effective factors were obtained and these are somewhat similar to four of the 11 factors obtained in the solutions for Models A and B. These are the factors which are identified by the body balance tests (1, 2, 3, and 4), the object-projection tests (7, 8, 10, 11, 12, and 9 in one of the two), the body-projection tests (27, 28, 29, 30, 31, and 9 appears on this factor), and finally the factor commented on in which variables 5, 16, 25, and 26 are grouped and which are bipolar with variable 21. The remaining variables (about one-third) do not appear to any extent on any of these four factors. For this reason, these solutions appear to be less satisfactory than those obtained for Models A and B.

Model D

Of the 20 effective factors obtained in this solution, 11 are specific to a single test item (variables 4, 5, 6, 13, 15, 16, 22, 24, 25, 26, and 30) and there are three factors, each with two variables, which are bipolar--2 and 14, 21 and 23, and 9 and 19. There are two doublets pairing 10 and 29 and 17 and 20, and a third doublet, variables 17 and 18, which is bipolar with variable 2. This last doublet was also obtained in the solutions for Models A and B but not for C. Note that, for the most part, these are the kinesthetic items and the two object-balance tests.

The remaining three factors are similar to three of the factors obtained in the solutions already discussed. One of these is identified by the body-balance tests, a second by the object-projection tests, and the third by the body-projection tests.

Summary

The variables which were categorized as object-projection, body-projection, and body-balance tests, in general, appeared on relevant factors in all of the seven solutions. The structure for the kinesthetic tests and the two ball balance tests was much less clear and varied considerably over the solutions. The tendency for some of the variables to disappear in the four-factor solution for Model C and to appear as specifics in the 20-factor solution for Model D is interesting. This would suggest that these variables have little in common.

UW - Strength Matrix

These data have not been previously analyzed or reported in the literature. They were collected at the University of Wisconsin and made available for this study. There were 29 variables and were categorized as follows: five measures of strength as measured by an instrument, seven measures of body projection, five measures of object-projection, and 12 measures of the ability to move or support the body weight against gravity. When these data were analyzed by the procedures used in this study, nine effective factors were obtained for Models A and B, 11 for Model C, and 16 for Model D. The results for Models A and B will be presented and discussed first, followed by the results for Model C, and finally the results for Model D. The solution given in the appendix is the derived orthogonal solution for Model B.

Models A and B

The five tests measuring strength by the use of an instrument are grouped into three factors. One factor is identified by the push, pull, and the trunk pull (variables 1, 2, and 14). The grip measure (variable 8) has low loadings on this factor also in the two orthogonal solutions but has higher loadings in all four solutions on a separate factor with variables 17, 29, and some of 13 and 14. The remaining variable in this category, knee extension (item 13) is grouped with the half-hold knee bend (variable 10) on a separate factor although variable 13 does have small loadings on the first factor described above in the two orthogonal solutions as well.

There were seven tests of body-projection. Six of these--leap, obstacle race, broad jump, foot bounce, dash, and shuttle run (variables 5, 23, 24, 27, 28, and 29)--appear on one factor. Items 5 and 29 also appear on other factors as well. Variable 12--the vertical jump--is with variable 9, the medicine ball put and other variables appear on this factor to some extent also.

The five object-projection tests (9, 15, 16, 17, and 25) all appear on one factor. However, variable 9 (medicine ball put) appears also with variable 12 as has already been mentioned.

The 12 tests of the ability to move or support the body weight are represented by three factors. One of these is identified by eight of these test items. The lunge right and left (items 18 and 19) appear together on a separate factor as does variable 11 (arm support), the latter being grouped with variable 5, the leap. There is no explanation for these two items appearing on the same factor.

Model C

Eleven effective factors were obtained for Model C and, in general, the results are quite similar to those obtained for Model A and B except for the category of tests called moving or supporting the body weight. For the dynamometric strength measures, three factors are obtained as in the results for Models A and B. There are also two factors for the body-projection items as in Models A and B, variable 12 is grouped with 9 as in the first group of solutions, and the remaining items appear on one factor except that the leap (variable 5) does not appear here but goes with some of the moving body weight tests. Variable 8 (grip) appears on this factor instead.

The five tests of object-projection are represented by two factors in the two solutions for Model C. In the derived orthogonal solution, one of these is similar to the factor obtained in the solutions for Models A and B. However, the additional factor is identified by variable 17 (tennis serve) which appears with variable 1 (push). The results for the derived independent cluster solution are somewhat different. Again two factors are obtained; one of these is variable 17 (tennis serve) with others such as 2, 6, etc. The second factor groups 15, 16, and 25 and variable 9 does not appear on this factor to any extent.

The results for the category of moving or supporting body weight items are again different for the two solutions for Model C. Four factors are obtained in both solutions but they differ to some extent. In the derived orthogonal solution, one factor is obtained which is almost identical to one of the factors obtained in Models A and B (variables 3, 4, 6, 7, 20, 21, 22, and 26 appear here). In addition, however, variable 22 appears on a separate factor along with items 5, 20, and 21. Another factor identified by variables 18 and 19 is obtained and this is the same factor obtained in the four solutions for Models A and B. Finally, variable 11 appears on another factor but not with variable 5 as in Models A and B but rather with some of item 26.

Four factors are also obtained for these test items in the derive independent cluster solution for Model C. One of these is identical with a factor obtained in all of the previously discussed solutions in which variable 18 and 19 appear together. Another factor is identical with the factor identified by variable 11 as obtained in the derived orthogonal solution for Model C. In addition, variables 3 and 4 appear with some of 6 as a factor and variables 20, 21, and 22 appear with some of 5 as a factor. These results are somewhat different than those previously presented for these test items. Finally, two variables in this category (items 6 and 26) are not clearly associated with any of these factors having small loadings on at least three different factors.

Model D

Sixteen effective factors were obtained for this solution, six of these were specific to a single test item (variables 8, 11, 13, 20, 23, and 26). The results for the five tests of strength as measured by an instrument are not identical with but are similar in some respects to the results already presented. One factor in which variable 13 appears with variable 10 is also obtained in this solution. As noted above, variable 13 is also specific to a factor as is variable 8 in this group. Two additional factors are obtained--one in which variables 1 and 2 appear together and a second in which variables 1 and 14 are grouped with some of 8.

For the tests of body-projection, three factors were obtained. Two of these are identical for all practical purposes with the two factors obtained for the solutions for Models A and B. The third is a factor specific to variable 23 (obstacle race).

The five tests of object-projection are grouped in a slightly different fashion as well. Variables 9, 15, 16, and 25 appear on one factor but variable 17 appears only on a separate factor with some of variable 1.

For the measures of moving or supporting the body weight, four of the factors are almost identical to those obtained in the derived orthogonal solution for Model C except that 11 appears as a specific rather than being grouped with the other test items. In addition, two specific factors are obtained--one associated with variable 20 and one with variable 26.

Summary

Models C and D have more factors than Models A and B and what occurs is a breaking up of the clustering of the object-projection tests into two factors, and the moving or supporting body weight tests into two factors. In addition, for Model D, there are five additional factors specific to a single test item.

Wendler Matrix

There were 45 variables in the original study and 15 of these were not included in this study. Most of the variables eliminated were indices. Eight of the variables involved object-projection items (although these tests are not all the same as though used in the previous studies in that some do not involve a maximum effort, i.e., item 12, the basketball target throw). There were three test items in which a ball had to be caught or fielded. Seven of the test items were body-projection tests and eight were tests of strength as measured by an instrument. The remaining four items were the Johnson Test Battery, the Brace Test, the Burpee, and the dodge turn with a soccerball.

When the data were factored by the procedures used in this study, four factors were obtained for the four solutions for Models A and B, five for the derived orthogonal solution for Model C, six for the derived independent cluster solution for Model C, and 11 for the derived orthogonal solution for Model D. However, the results obtained were similar enough, except for the singlets obtained in Model D, so that the results for all of the solutions could be discussed in a single section. The solution given in the appendix is the derived independent cluster solution for Model B.

Models A, B, C, and D

One of the factors obtained is identified by the seven body-projection tests-circling bases, bar vault, 60-yd. dash, potato race, standing broad jump, running high jump, and the sargent jump (variables 5, 14, 15, 16, 17, 18, and 20); the dodge turn with soccerball (variable 9 has its highest loadings on this factor as well. Variable 21 (Brace test) also has substantial loadings on this factor but appears on others as well. The appearance of variable 9 is logical in that it does involve a run while kicking a soccerball and this performance is apparently more highly related to running than the handling of the object. In addition, some of variables 4, 18, 19, 22, 24, and 28 appear in some of the solutions.

In all of the solutions except the derived independent cluster solution for Model C, a second factor is identified by the six tests of strength as measured by an instrument--pectoral, arm flexor, thigh flexor, leg extensor, leg lift, back lift (variables 23, 24, 25, 26, 27, and 28). Three other tests have their highest loadings on this factor--shot put (variable 19) and chin and dip strength (variables 29 and 30). As many as 10 other variables also appear on this factor in the orthogonal solutions with many less in the independent cluster solutions for Models A and B. In the derived independent cluster solution for Model C. variables 27, 28, 29, and 30 are grouped on a factor with some of 24 and 26. However, variables 23, 25, and 26 with some of 24 appear on a second factor.

A third factor is identified in all seven solutions by variables 1, 2, 3, 4, 6, 7, and 10 (these all involve object-projection or reception). In the orthogonal solutions variables 8 and 11 also have substantial loadings on this factor and 11 and 12 have small loadings in the independent cluster solutions. Variables 4, 5, 9, 16, and 19 also appear on this factor to a limited extent in some of the solutions.

A fourth factor is identified in all of the solutions by variables 8, 11, 13, 21, and 22 (kick a soccerball, dribbling a basketball, Johnson Test, Burpee, and the Brace Test). Variables 10 and 12 also appear to some extent in some of the solutions and variable 4 has a negative loading on this factor in all of the derived independent cluster solutions. This factor is difficult to identify.

This explains four of the factors common to the seven solutions. The fifth factor obtained in the derived orthogonal solution for Model C is a singlet specific to variable 12 (basketball target throw). The fifth factor obtained for the derived independent cluster solution for Model C has already been commented on and the sixth is a bipolar factor grouping variables 4 and 16 with variable 6 having a negative loading.

For Model D, in addition to the four factors common to all of the solutions, there are six singlets specific to variables 4, 6, 8, 10, 12, and 25 and there is a bipolar factor--variable 2, positive and variable 2, negative.

Summary

Four factors are common to all seven of the solutions, although the structure for one of these factors is somewhat different in the derived orthogonal solution for Model C. The variables identifying the factor are represented on at least two factors in this solution but there is not a clear breaking up into smaller clusters. Except for the singlet obtained in the derived orthogonal solution for Model C, six of the solutions have considerable similarity. In the derived orthogonal solutions, a large number of variables appear on at least two of the factors. This is not true for the derived independent cluster solutions.

Comparison With the Original Solution

Wendler used Thurstone's multiple factor procedures and obtained four factors in his analysis of the data. Three of these were reproduced in the results obtained in the analyses made in this study. His fourth factor includes variables 1, 2, 3, 6, 8, 10, 11, 12, 13, and 22. No such factor was obtained in this study; however, some of these--variables 8, 11, 13, 21 and 22--appeared on one factor. Thus the results of this study tend to support three of Wendler's factors but not the fourth. The fourth factor in the two investigations does have certain variables in common, however.

Summary of the Findings

1. The various derived independent cluster solutions were bipolar (with few exceptions), indicating that the variables must be regarded as factorially complex in that they are associated with two or more factors.

2. For seven of the 10 matrices, the derived orthogonal solutions were also bipolar whereas for three of the matrices the derived orthogonal solutions gave a positive manifold. For seven of the 10 matrices (although not the same seven), a substantial number of the variables were of complexity greater than one, whereas in the remaining three only a few of the variables appeared to be of complexity greater than one.

3. The major difference across methods for a given matrix is in the number of distinct clusters identified, with a solution that yields fewer effective common factors coalescing distinct clusters found in a solution which yields a greater number of effective common factors.

4. The solutions derived using Joreskog's procedures tended to be somewhat inconsistent with the solutions derived from the other three procedures.

5. A number of factors appear to be reasonably robust when an adequate number of variables is included in the analysis so as to permit the distinctive clusters to appear. For example, for variables involving the projection of the body, factors associated with jumps, with longer straight runs, and with runs involving quick change of direction appear. However, when these types of variables are sampled on a limited basis, the resulting analysis tends to collapse these factors. Similar findings exist for these classes of variables: object projection, strength as measured by an instrument, moving or supporting the body weight against gravity, and abdominal strength as measured by sit-ups, V-sit, etc.

FINDINGS: GUILFORD MATRICES

In this section we shall discuss each of the matrices in turn. We present in the appendix tables of factor coefficients for each of the matrices. These tables give derived results for only one of our methods for each matrix. In general, we do not present in these tables any of the derived oblique solutions. The reasons for this are two: first, in nearly every instance the derived oblique solution was bipolar (aside from rational reflections), thus indicating that the hypothesis that the variables could be regarded as a set of independent (but correlated) clusters in the factor space should be rejected. This is an important finding in itself, since the theory presented by Harris and Kaiser (Harris and Kaiser, 1964) clearly shows that if for a set of variables each variable is of complexity one, in the factor space, the derived oblique solution employed here will reveal this numerically. The bipolarity we observed contradicts this hypothesis. Thus, our methods do not demonstrate univocal factors for the Guilford matrices we studied. The second reason is that Guilford's original results are consistently given as derived orthogonal solutions; thus it seems most fair, for comparison with Guilford's interpretations of the factors, to use the orthogonal solutions yielded by our methods.

We also have consistently chosen either Model B or Model D for the illustrative solution for each matrix. Two grounds for this are: Model A, as was indicated in Table 2, does not fit the observed correlations nearly as well as any of the other three, and Model C (Joreskog solution) was unsatisfactory at the theoretical level for about half the matrices, as indicated by the magnitude of the Joreskog constant. However, there is considerable similarity among the derived orthogonal solutions for the various models, and the selection of either Model B or Model D to discuss does not conceal or ignore radically different results secured from the other models.

Matrix 08

We present Model B, derived orthogonal solution, in the appendix. Seven of the factors identified by Guilford are fairly clearly reproduced here. These are: Verbal Comprehension, Vizualization, Numerical Facility, Doublet, Ideational Fluency, Sensitivity to Problems, and Word Fluency. (Capitalized terms are those of Guilford.) In addition, Guilford's Originality and his Spontaneous Flexibility, which he secured as separate factors, come together on our factor 2, and his Perceptual Speed and his Closure come together on our factor 3. This collapsing or coalescing of factors was found a number of times. It is of some importance to note that this is, certainly in this instance, not entirely a function of extracting an inadequate number of factors, since our Model B solution has 14 effective factors compared with Guilford's 15 effective factors. Further, Model D which surely extracted more than "enough" factors shows this same coalescing in the derived orthogonal solution. In addition, one of our factors (number 9) is similar to Guilford's Redefinition. Of the remaining four factors in our solution, three are singlets and the fourth is not related to any of Guilford's.

The seven factors listed at the beginning of the previous paragraph appear to be reasonably robust with respect to variations in methodology; some of these same factors exhibit this same robustness for other matrices, as will be pointed out below. For this matrix our solutions raise a question of the independence, as factors, of Originality and Spontaneous Flexibility, and of Perceptual Speed and Closure. Our solutions give no evidence that factors of General Reasoning, Associational Fluency, and Adaptive Flexibility--identified by Guilford--survive these variations in methodology.

Matrix 09

Our results for this matrix present a number of problems. For one, Model D extracted a very large number of factors, and Model C went to 46 factors--a trivial solution. The derived orthogonal solution for Model D yields a very large number of singlets, and the remaining factors are often doublets. These two models, then, suggest a high degree of specificity for this set of variables. Model B yielded two singlets and three doublets in the derived orthogonal solution. This solution is given in the appendix.

Of the remaining 10 factors (ignoring the singlets and doublets) a few correspond with Guilford's results. Our factor 1 is probably his Logical Evaluation, our factor 2 his Vizualization, our factor 8 his Speed of Evaluation (but somewhat broader), and our factor 11 his Perceptual Speed. Our factor 7 appears to include his Verbal Classification, but again is somewhat broader. Our factors 3 and 12 both have rather strong verbal comprehension components, but neither one duplicates his Verbal Comprehension. Our factors 4 and 6 suggest, but rather inadequately, Guilford's Ideational Fluency and Perceptual Evaluation. On the other hand, our factor 13 has no match in Guilford's results. In general, then, our results for this matrix set problems of interpretation that are much more serious than those for Matrix 08. It is interesting to note that both 08 and 09 include about the same number of variables, and that our Model B solution gives about the same number of common factors to be interpreted, but that the correspondences with the Guilford solutions seem to be much less evident for 09.

Matrix 12

For Matrix 12 we present the Model D derived orthogonal solution in the appendix. This solution yielded a large number of initial factors, a smaller effective number of factors, and a still smaller effective number of common factors. As Table 6,indicates, our Model D solution differs markedly from the original Guilford solution in number of common factors--eight as opposed to 14. Of these eight common factors, five tend to correspond to Guilford's results; these are factors of Verbal Comprehension (but somewhat broader in our solution than in Guilford's), Adaptive Flexibility, Numerical Facility, Education of Conceptual Relations, and a portion of Guilford's Judgment factor. In addition, our factor 2 combines Guilford's Elaboration and his Conceptual Foresight. The remaining two factors consist of a bipolar doublet (factor 6) and a factor that seems to have little correspondence with Guilford's results (factor 7).

The solution for Model B is very similar to the one presented here with respect to common factors; Model D has a larger number of singlets. The presence of a relatively large number of singlets in the derived orthogonal solution for Model D was a fairly consistent finding for the various Guilford matrices. (Compare Tables 4 and 6 to observe this.) The solution for Matrix 12 given in the appendix gives a specific illustration of this phenomenon.

Matrix 14

We present the derived orthogonal solution for Model D in the appendix. Again, we have an illustration of the relatively large number of singlets that were produced by this model. For this matrix both Model B and Model D give Guilford's Verbal Comprehension and his Eduction of Patterns factors. Model B duplicates his Mathematics Achievement and his Numerical Facility factors, but collapses Vizualization and his General Reasoning into one factor; also it collapses his Handling Complicated Procedures and his Trial and Error Manipulation into one factor. On the other hand, Model D duplicates his Logical Evaluation factor (factor 4), gives what may be a part of his General Reasoning (factor 3), a part of his Trial and Error Manipulation (factor 3), and a part of his Handling Complicated Processes (factor 10). The remaining factor (factor 1) has parts of three of Guilford's factors: Vizualization, General Reasoning, and Handling Complicated Procedures.

Matrix 16A

For Matrix 16A we present the Model D solution in the appendix. Of the 10 common factors identified by Guilford (ignoring his 11th common factor which is a doublet), our solution corresponds well for the factors Symbol Substitution (factor 2), Eduction of Correlates (factor 3), Eduction of Patterns (factor 8), and Symbol Manipulation (factor 9). We also secure at least a part of Guilford's Eduction of Perceptual Relations (factor 4), and a part of his General Reasoning (factor 7). Our first factor coalesces Guilford's Education of Conceptual Relations, his Verbal Classification, and his Expressional Fluency. The remaining Guilford factor is Verbal Comprehension, which we do not identify in our solution. Our solution differs from his also in that it yields four singlets.

Matrix 16B

We present the solution for Model D in the appendix. For this model, the solution corresponds with Guilford's in identifying his Eduction of Perceptual Relations (factor 2), his Verbal Comprehension (factor 3), his Associational Fluency (factor 4), and his Eduction of Structural Relations (factor 5). Of these, all except Verbal Comprehension are also identified in the Model B derived orthogonal solution; for this solution Verbal Comprehension is coalesced with two other factors. Our Model D solution also gives a part of Guilford's Expressional Fluency (factor 1) and a part of Naming Abstractions (factor 8). In the Model B solution these two factors coalesce with the Verbal Comprehension factor. In addition, our Model D solution gives a second factor that is verbal in nature (factor 7), but is not well defined; the Model B solution also gives a second factor that is verbal in nature. Our factors 6 and 10 are each singlets.

Matrix 16C

Again we present the solution for Model D in the appendix. This solution identifies Guilford's Penetration (factor 1) but may be somewhat broader here than in his analysis, his Ideational Fluency (factor 6), his Eduction of Structural Relations (factor 7), and his Spontaneous Flexibility (factor 9). We reproduce, partially, Guilford's Judgment (factor 3) and his Originality (factor 4); also we put together his Associational Fluency and his Verbal Comprehension in our factor 2. Our remaining common factor (factor 5) bears no obvious correspondence with Guilford's results.

The three studies represented in matrices 16A, 16B, and 16C include overlapping variables. Thus, in many instances, Guilford identifies the same factor in two or possibly three of the studies. He makes 29 identifications. Our results, when we count as an identification at least a rough match either standing as a separate factor or combined with one or more other factors, give 23 identifications--a sizable percentage. However, if we exclude the identifications in which two or more factors are combined, this reduces to 18 identifications in our results, approximately 60 per cent. This probably is a satisfactory rough index of the extent to which the methods we used reproduce the results from Guilford's laboratory; it tends to hold for the other matrices as well as this set of three.

Matrix 22

We present the Model D solution in the appendix. Recall that for this matrix, the alpha solution (Model B) did not converge. Of the eight effective common factors, all except two can be identified fairly unambiguously with the factors secured by Guilford. Note, however, that Guilford secured more common factors than we did.

Guilford's Ideational Fluency (factor 1), his Verbal Comprehension (factor 3), his Sensitivity to Problems (factor 4), his Cartoons Specific (our factor 5, a doublet), and his Convergent Production of Semantic Classes (factor 7) are evident in our results. Our factor 2 is somewhat broader than his Eduction of Conceptual Relations, but includes the variables he uses to identify this factor. Our factor 6 appears to be a part of Guilford's Conceptual Classification, but certainly is not well defined since the two tests demanding verbal classification do not appear on it. (In our solution these two tests go with the Eduction of Conceptual Relations factor.) Our remaining common factor (factor 19) does not bear marked resemblance to any of Guilford's.

Perhaps it is worth noting that this matrix included a random variable; in our solution this comes out as a singlet (factor 9). The behavior of this random variable here and in Guilford's solution is rather interesting. Guilford secured three coefficients of absolute value of .20 or greater in his rotated solution, and a communality of .18. In our solution the communality was higher--.30--but with only the one coefficient greater than .07 in absolute value. It is consistent with the underlying theory on which it is based to except that Model D will capitalize on small correlations (our communality of .30 as opposed to Guilford's communality of .18) and thus suggest to the unwary that a variable has a certain amount of "reliable" variance even though, as in this case, it is known to be a random variable. Our rotation procedure, however, clearly set this random variable aside on a singlet factor and did not link it up, in the rotated solution, with any other variables. Perhaps the phenomenon exhibited here is useful as a caution; the interpretation of any singlet factor is extremely tenuous.

Matrix 23

For this last matrix we present the derived orthogonal solution from Model D in the appendix. The Model B solution has five of the seven common factors of

Model D and thus reproduces the Model D solution in part. Three of our common factors are easily identified as Guilford's Cognition of Symbolic Classes (factor 3), his Verbal Comprehension (factor 5), and his Numerical Facility (factor 9). Our solution probably gives a somewhat better definition of Verbal Comprehension and of Numerical Facility than does Guilford's. Our factors 1 and 2 are both a combination of several of Guilford's factors. For example, Convergent Production of Symbolic Systems, Cognition of Symbolic Implications, Eduction of Patterns, Eduction of Symbolic Relations, and General Reasoning appear to have been put together on our factor 1. Our factor 2 combines Guilford's factors of Cognition of Symbolic Units, Symbolic Redefinition, and Word Fluency. Our factor 4 is difficult to interpret; it is a doublet linking two tests that involve pictures and may be specific to that type of material, but it also may be a part of Guilford's Naming Abstractions. Our factor 6 does not reproduce one of Guilford's factors; however, it is a sensible doublet in that both tests require the analysis of spelling or of alphabetical features of meaningful words in order to respond.

The results for this matrix illustrate again possible effects of methodological variation. As Table 2 and Table 4 indicate, our Model D solution began with "enough" factors to reproduce nearly all of the Guilford's 13 factors that he interpreted. However, our rotation procedure developed a large number of singlets and at the same time combined Guilford factors, noticeably in our factors 1 and 2. This combining of factors is not completely inconsistent with Guilford's results however; for example, his factor Cognition of Symbolic Units is identified by variables every one of which has a secondary loading on one of the other two factors that coalesced with it into our factor 2. Since it is not our purpose in this study to argue the question of who is right (possibly a silly question in itself), we merely point out these differences and similarities as evidence of the effects of methodological variables on the final substantive picture.

Summary of the Findings

For the Guilford matrices which we analyzed in these various ways, we observe:

1. The various derived independent cluster solutions were bipolar, thus contradicting the hypothesis that the variables could be regarded as of complexity one. Instead, at least some of the variables employed in each of these studies must be regarded as factorially complex in that they are associated with two or more factors. This is probably a major finding for these matrices.

2. The various derived orthogonal solutions tended to give a positive manifold, with at least some of the variables of complexity greater than one.

3. The alpha derived orthogonal solution and the incomplete image derived orthogonal solution are reasonably consistent in the interpretations of the factorial structure of the variables that they suggest, the major differences being that usually the alpha solution gives fewer effective common factors.

4. It was not possible, using the methods we employed, to duplicate completely Guilford's results. In part, this is a function of the differences between our methods and his in the number of factors extracted and retained after rotation. As an extreme example, for one of the matrices the five-factor derived alpha solution simply coalesced or collapsed 11 of Guilford's factors into five, and failed to give an indication of two other Guilford factors. For another matrix, eight of Guilford's factors were duplicated reasonably well, four of his were collapsed into two, and three of his were not found in our solutions.

5. Certain factors identified by Guilford tend to appear fairly consistently in our solutions. Verbal Comprehension, Numerical Facility, Word Fluency, Ideational Fluency, and Vizualization appear to be reasonably robust factors.

CONCLUSIONS

The comparison of factorial methods applied to data drawn from two domains of content yields valuable empirical evidence about the extent to which substantive conclusions may be a function of the methodology employed. In one sense, the methodological variables we studied are strong variables, particularly with respect to the initial solutions. However, the derived solutions tend to give much more consistent suggested interpretations. In general, then, the development of a derived solution appears to be an important part of any adequate factorial study.

Of the three relatively new methods employed, the Joreskog procedure appears to be less satisfactory than either the alpha or the incomplete image analysis. These latter two appear to be the methods of choice among the four methods studied, on the grounds of adequate approximation to the data. A choice between these two involves essentially a preference for level of specificity.

The routine use of the normal varimax procedure to secure a derived orthogonal solution appears to be a generally satisfactory procedure. However, for sets of variables that consist of independent, but correlated, clusters the derived independent cluster solution gives a less ambiguous interpretation. This method, used here extensively for the first time, essentially tests the hypothesis that the variables can be so regarded. This hypothesis was rejected in a number of instances in this study. A routine use of this method would be recommended as a desirable practice, with the interpretation of any study to be based on both the derived orthogonal and the derived oblique solution.

A comparison of the derived factors secured by the various methods employed in this study with the factors identified and interpreted by the original investigator reveals considerable variation in the extent to which the original results can be duplicated. In some instances there was considerable correspondence; in

others, relatively little. Therefore, our major conclusion is that substantive findings from a particular laboratory may be in part a function of the methods employed. In all domains, the factors that are robust with respect to methodological variation need to be identified and given a large weight in the construction of any model for the domain.

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APPENDIX

Table 7

Brogden, Model B, Derived Orthogonal Solution

Factor 1

5	Vertical Jump	.69
6	Standing Broad Jump	.66
7	Broad Jumps	.61
8	Vault	.57
9	Hop-Step-Jump	.52
10	200-Yd. Run	.34
12	250-Yd. Shuttle (50-Yd. Laps)	.31
15	Obstacle Course	.30
16	100-Yd. Shuttle (20-Yd. Laps)	.32
17	Rope Climb	.65

Factor 2

15	Obstacle Course	.31
17	Rope Climb	.37
18	Chins	.72
19	Floor Push-Ups	.74
20	Burpee	.41
21	Sit-Ups	.43
22	Dips	.74
23	Ankle-to-Bar	.61

Factor 3

1	Softball Throw	.78
2	Medicine Ball Put	.78
3	Medicine Ball Throw	.80
4	Basketball Throw	.80
6	Standing Broad Jump	.41
7	Broad Jumps	.31
9	Hop-Step-Jump	.33
10	300-Yd. Run	.37

Factor 4

12	250-Yd. Shuttle (50-Yd. Laps)	.38
13	Dodge Run	.43
14	Hurdle Run	.58
15	Obstacle Course	.51
16	100-Yd. Shuttle (20-Yd. Laps)	.63
18	Chins	.32
20	Burpee	.37

Factor 5

9	Hop-Step-Jump	.30
10	300-Yd. Run	.57
11	100-Yd. Shuttle (50-Yd. Laps)	.72
12	250-Yd. Shuttle (50-Yd. Laps)	.68
13	Dodge Run	.30
16	100-Yd. Shuttle (20-Yd. Laps)	.35

Table 8

Cousins, Model B, Derived Independent Cluster Solution

Factor 1		
2	Pull-Ups	.36
9	Running Broad Jump	.45
10	Shot Put (16 lbs.)	.59
15	Vertical Jump	.77
16	Standing Broad Jump	.96
22	Standing Hop-Step-Jump	.48
24	150-Yd. Dash	.36
27	Medicine Ball Put	.75
28	3 Standing Broad Jumps	.82
31	200-Yd. Shuttle	.46
Factor 2		
5	Push-Ups	.46
6	Squat Jumps	.72
17	Dips	.63
29	Leg Lifts	.61
Factor 3		
7	100-Yd. Pick-a-Back	.89
11	75-Yd. Pick-a-Back	.67
Factor 4		
3	300-Yd. Shuttle	.72
18	250-Yd. Shuttle	.72
25	220-Yd. Dash	.50
31	200-Yd. Shuttle	.43
Factor 5		
4	60-Sec. Squat Thrusts	.34
8	20-Sec. Squat Thrusts	.69
23	75-Yd. Dash	.37
Factor 6		
1	Sit-Ups	.75
4	60-Sec. Squat Thrusts	.31
14	Straddle Chins	.42
19	2-Min. Sit-Ups	.51
26	Hurdle Run	.38

Table 8, continued

Factor 7

10	Shot Put (16 lbs.)	.32
12	Dodging Run	.55
17	Dips	-.39
26	Hurdle Run	.53
30	300-Yd. Run	.30

Factor 8

20	20-Ft. Rope Climb	.79

Factor 9

13	6-Sec. Run	.68
21	100-Yd. Dash	.66
23	75-Yd. Dash	.72
24	150-Yd. Dash	.31
25	220-Yd. Dash	.30
30	300-Yd. Run	.32

Table 9

Cumbee, Model B, Derived Orthogonal Solution

Factor 1		
1	30-Sec. Rod Balance	.57
2	30-Sec. Rod Balance, Replacement	.89
3	2 Rod Balance	.71
4	Dynamic Balance	.32
15	Soccer Kicks	.36
16	Basketball Throw	.37
Factor 2		
9	Crosses and Vertical Lines	.46
10	Nose and Ear	.53
Factor 3		
6	Tempo-Long-Short	.44
7	Tempo-Arm Exercises	.60
8	Tempo-Total Body	.30
Factor 4		
4	Dynamic Balance	.59
5	Static Balance	.33
19	Johnson 3	.77
20	Johnson 4	.40
Factor 5		
11	Stick Placing	.51
12	Block Tapping	.58
Factor 6		
13	Burpee	.37
14	Short Potato Race	.67
15	Soccer Kicks	.41
16	Basketball Throw	.56
17	Ball Catching	.52
18	Ball Striking	.31
19	Johnson 3	.31
21	Jump and Reach	.49

Table 10

Fleishman-Speed, Model B, Derived Independent Cluster Solution

Factor 1		
8	Arm Circling	.36
13	Dodge Run	.35
14	Shuttle Run	.52
15	Circle Run	.71
16	Figure 8-Duck	.66
17	Grass Drill	.65
18	Soccer Dribble	.36
Factor 2		
20	1-Ft. Length Balance, Eyes Closed	.61
23	2-Ft. Cross Balance, Eyes Open	.63
24	2-Ft. Cross Balance, Eyes Closed	.72
27	Rail Walking	.40
Factor 3		
3	Twist and Touch	.65
7	Plate Tapping	-.48
Factor 4		
4	Squat, Twist, and Touch	.69
5	Bend, Twist, and Touch	.55
6	Lateral Bend	.53
7	Plate Tapping	.32
9	Block Transfer	.57
21	1-Ft. Cross Balance, Eyes Open	-.31
Factor 5		
11	2-Ft. Tapping	.54
22	1-Ft. Cross Balance, Eyes Closed	-.31
30	Ball Balance	.47
Factor 6		
19	1-Ft. Length Balance, Eyes Open	.52
21	1-Ft. Cross Balance, Eyes Open	.46
28	Board Balance	.36
29	Stick Balance	.45
Factor 7		
10	1-Ft. Tapping	.64
12	Leg Circling	.62
17	Grass Drill	.30
27	Rail Walking	.49

Table 10, continued

Factor 8

1	Abdominal Stretch	.65
2	Toe Touch	.42

Factor 9

22	1-Ft. Cross Balance, Eyes Closed	.47
25	2-Ft. Length Balance, Eyes Open	.73
26	2-Ft. Length Balance, Eyes Closed	.41

Table 11

Fleishman-Strength, Model B, Derived Independent Cluster Solution

Factor 1		
2	Push-Ups (15 Sec.)	.33
4	Deep Knee Bends	.34
13	Rope Climb	.78
14	Dips (10 Sec.)	.77
16	Dips (To Limit)	.81
20	Bent Arm Hang	.56
22	Chins (Limit)	.80
24	Chins (20 Sec.)	.64
27	Medicine Ball Put (Sit)	-.44
30	Push-Ups (Limit)	.58
Factor 2		
8	Hand Grip	.82
10	Arm Pull, Dynamometer	.72
12	Trunk Pull, Dynamometer	.58
25	Medicine Ball Put (Stand)	.50
Factor 3		
5	Sit-Ups	.40
15	Vertical Jump	.73
17	Standing Broad Jump	.74
19	10-Yd. Dash	.77
21	50-Yd. Dash	.84
23	Shuttle Run	.89
24	Chins (20 Sec.)	.32
27	Medicine Ball Put (Sit)	.30
29	Softball Throw	.50
Factor 4		
1	Leg Lifts	.52
18	Leg Raiser	.41
26	Half Hold Sit-Ups	.82
Factor 5		
4	Deep Knee Bends	.31
7	Pull Weights, Arms	.78
9	Push Weights, Arms	.80
11	Push Weights, Feet	.53
27	Medicine Ball Put (Sit)	.43

Table 11, continued

Factor 6

3	Reverse Sit-Ups	.45
28	Half Hold Push-Ups	-.42

Factor 7

2	Push-Ups (15 Sec.)	.41
6	Squat Thrusts	.72
28	Half Hold Push-Ups	.42

Table 12

McCraw, Model D, Derived Orthogonal Solution

Factor 1		
1	50-Yd. Dash	.50
2	Jump and Reach	.56
3	Standing Broad Jump	.44
4	Basketball Throw	.69
8	Sit-Ups	.36
11	Wall Volley	.75
12	Ball Bounce	.74
13	Target Toss	.67
Factor 2		
1	50-Yd. Dash	.42
3	Standing Broad Jump	.49
6	Pull-Ups	.54
7	Push-Ups	.52
8	Sit-Ups	.35
Factor 3		
14	Tangle Test	.51
15	Rhythm	.49
Factor 4		
1	50-Yd. Dash	.41
2	Jump and Reach	.32
3	Standing Broad Jump	.33
5	Potato Race	.49
Factor 6		
9	10-Sec. Squat Thrusts	.59
10	30-Sec. Squat Thrusts	.48
Factor 7		
8	Sit-Ups	.31

Table 13

Phillips, Model D, Derived Orthogonal Solution

Factor 1

1	Obstacle Race	.63
2	20-Yd. Hop	.62
3	Agility Run	.69
4	Humiston Motor Ability	.54
6	Bass Balance	.34
8	Side Step	.47
9	Iowa Brace	.42
10	Burpee	.46
13	Jump and Reach	.52
14	Basketball Throw	.55
15	Standing Broad Jump	.68
23	Dips	.32

Factor 2

5	V-Sit	.40
11	30-Sec. Sit-Ups	.84
12	1-Min. Sit-Ups	.84
16	Sit-Ups (No. Possible)	.59

Factor 3

18	Right Grip	.74
19	Left Grip	.74
20	Back Strength	.40

Factor 4

22	Chins	.48
23	Dips	.58

Factor 5

5	V-Sit	.52
7	Half Sit Hold	.60

Factor 6

20	Back Strength	.70
21	Leg Strength	.73
24	Spirometer	.37

Factor 8

1	Obstacle Race	.36
8	Side Step	.52

Table 13, continued

Factor 9		
4	Humiston Motor Ability	.40
Factor 10		
6	Bass Balance	.49
9	Iowa Brace	.44
Factor 11		
13	Jump and Reach	.37
Factor 12		
17	Brouha	.42

Table 14

UW-Balance, Model B, Derived Independent Cluster Solution

Factor 1		
8	Overarm Throw, Eyes Closed	.45
23	Volleyball Toss, Duplicated-Eyes Open	.66
Factor 2		
1	1-Ft. Lengthwise Balance, Eyes Open	.43
7	Overarm Throw, Eyes Open	.72
8	Overarm Throw, Eyes Closed	.33
11	Basketball Throw, Eyes Open	.89
12	Basketball Throw, Eyes Closed	.85
17	Push (Dynamometer)	-.30
Factor 3		
13	Lower Leg Raise	.55
14	Arm Raise	.47
26	Basketball Toss, Duplicated-Eyes Closed	-.33
Factor 4		
10	Volleyball Serve	.36
15	Lower Arm Raise	-.50
25	Basketball Toss, Duplicated-Eyes Open	.38
26	Basketball Toss, Duplicated-Eyes Closed	.63
Factor 5		
14	Arm Raise	-.33
22	Vertical Jump, Duplicated-Eyes Closed	.58
31	Obstacle Race	.39
Factor 6		
5	Ball Balance, Eyes Open	.53
6	Ball Balance, Eyes Closed	.39
16	Leg Raise	.48
21	Vertical Jump, Duplicated-Eyes Open	-.88
25	Basketball Toss, Duplicated-Eyes Open	.34
31	Obstacle Race	.38
Factor 7		
16	Leg Raise	-.30
17	Push (Dynamometer)	.39
20	Broad Jump (Specified)	.70

Table 14, continued

Factor 8

2	1-Ft. Lengthwise Balance, Eyes Closed	-.31
17	Push (Dynamometer)	.40
18	Pull (Dynamometer)	.81

Factor 9

19	Knee Flexion	.71
28	50-Yd. Dash	.37

Factor 10

1	1-Ft. Lengthwise Balance, Eyes Open	.43
2	1-Ft. Lengthwise Balance, Eyes Closed	.73
3	1-Ft. Crosswise Balance, Eyes Open	.60
4	1-Ft. Crosswise Balance, Eyes Closed	.86
25	Basketball Toss, Duplicated-Eyes Open	-.36
30	Foot Bounce	.44

Factor 11

9	Tennis Serve	.39
27	Broad Jump	.85
28	50-Yd. Dash	.51
29	Shuttle Run	.74
30	Foot Bounce	.49

Table 15

UW-Strength, Model B, Derived Orthogonal Solution

Factor 1		
3	Deep Knee Bend (Sec.)	.80
4	Deep Knee Bend (No.)	.80
5	Leap	.31
6	Half Hold Push-Up (Sec.)	.67
7	Travel Ladder	.69
11	Arm Support (Sec.)	.38
20	Seal Walk	.73
21	Rope Pull-Up	.79
22	Bent Arm Hang	.58
26	Chins, Modified	.64
27	Foot Bounce	.46
Factor 2		
9	Medicine Ball Put	.51
15	Overarm Throw	.83
16	Volleyball Serve	.80
17	Tennis Serve	.47
25	Basketball Throw	.49
27	Foot Bounce	.33
Factor 3		
5	Leap	.57
21	Rope Pull-Up	.30
23	Obstacle Race	.66
24	Broad Jump	.72
26	Chins, Modified	.33
27	Foot Bounce	.48
28	50-Yd. Dash	.73
29	Shuttle Run	.60
Factor 4		
9	Medicine Ball Put	.37
18	Lunge Right Leg (Sec.)	.76
19	Lunge Left Leg (Sec.)	.85
Factor 5		
9	Medicine Ball Put	.33
10	Half Hold Knee Bend (Sec.)	.81
13	Knee Extension (Lbs.)	.64

Table 15, continued

Factor 6		
1	Push (Lbs.)	.84
2	Pull (Lbs.)	.76
5	Leap	.37
8	Grip Strength	.39
13	Knee Extension (Lbs.)	.35
14	Trunk Pull	.61
25	Basketball Throw	.40
Factor 7		
5	Leap	-.46
11	Arm Support (Sec.)	.68
Factor 8		
3	Deep Knee Bend (Sec.)	.30
9	Medicine Ball Put	.46
12	Vertical Jump	.68
Factor 9		
8	Grip Strength	.47
17	Tennis Serve	.32
29	Shuttle Run	-.49

Table 16

Wendler, Model B, Derived Independent Cluster Solution

Factor 1

10	Shooting Baskets	.42
12	Basketball Target Throw	.43
19	Shot Put (8 lbs.)	.74
21	Brace Test	-.45
23	Pectoral Strength	.97
24	Arm Flexor Strength	.72
25	Thigh Flexor Strength	.79
26	Leg Extensor Strength	.92
27	Leg Lift	.94
28	Back Lift	.79
29	Chin Strength	.73
30	Dip Strength	1.10

Factor 2

1	Fielding a Groundball	.90
2	Throwing a Baseball	.85
3	Catching a Flyball	.82
4	Batting	.42
6	Throwing a Soccerball	.58
7	Catching a Soccerball	.64
10	Shooting Baskets	.39
11	Dribbling a Basketball	.31

Factor 3

4	Batting	-.40
8	Kicking a Soccerball	.36
11	Dribbling a Basketball	.60
12	Basketball Target Throw	.31
13	Johnson Test	.86
21	Brace Test	.36
22	Burpee Test	.58

Factor 4

4	Batting	.37
5	Circling Bases	.93
9	Dodge Turn With Soccerball	.63
14	Bar Vault	.73
15	60-Yd. Dash	.84
16	Potato Race	.74
17	Standing Broad Jump	.72
18	Running Broad Jump	.55
20	Sargent Jump	.97
21	Brace Test	.77
24	Arm Flexor Strength	.39

Table 17

Guilford 08, Model B, Derived Orthogonal Solution

Factor 1		
1	Sentence Analysis	.32
2	Paragraph Analysis	.35
11	Number Associations (uncommonness)	.31
15	Circle Square II	.43
17	Sign Changes	.35
18	Implied Uses	.37
27	Sentence Gestalt (Omissions)	-.54
32	Concept Synthesis	.37
33	Sentence Synthesis	.64
34	Word Matrices	.35
43	Vocabulary	.68
44	Ship Destination	.35
46	Inference Test	.63
52	Arithmetic Reasoning	.39
53	Sentence Gestalt	.46
Factor 2		
1	Sentence Analysis	.35
3	Figure Analysis	.47
4	Figure Concepts (Uncommonness)	.53
5	Impossibilities	.46
7	Plot Titles (Cleverness)	.44
8	Common Situations	.57
9	Brick Uses (Fluency)	.52
10	Brick Uses (Flexibility)	.52
11	Number Associations (Uncommonness)	.51
13	Consequences Test (Remoteness)	.62
18	Implied Uses	.38
19	Quick Responses (Uncommonness)	.33
20	Associations I	.45
22	Unusual Uses	.67
23	F-Test	.30
24	Apparatus Test	.33
25	Social Institutions (Direct Implications)	.30
31	Object Synthesis	.34
39	Controlled Associations	.52
41	Unusual Details	.32
Factor 3		
35	Punched Holes	.32
36	Mutilated Words	.36
37	Street Gestalt Completion	.62
38	Perceptual Speed	.58
41	Unusual Details	.33
42	Penetration of Camouflage	.67
47	Spatial Orientation Test (Part I)	.54

Table 17, continued

Factor 4		
16	Match Problems	.38
35	Punched Holes	.49
48	Practical Judgment	.47
51	Mechanical Principles	.71
52	Arithmetic Reasoning	.44
Factor 5		
47	Spatial Orientation Test (Part I)	.30
49	Numerical Operations Test (Part I)	.76
50	Numerical Operations Test (Part II)	.70
52	Arithmetic Reasoning	.45
Factor 6		
24	Apparatus Test	.34
26	Social Institutions (Indirect Implications)	.63
Factor 7		
7	Plot Titles (Cleverness)	.51
Factor 8		
16	Match Problems	.32
45	Symbol Manipulation	.40
Factor 9		
19	Quick Responses (Uncommonness)	-.30
29	Gestalt Transformation	.50
30	Picture Gestalt	.48
Factor 10		
31	Object Synthesis	-.37
Factor 11		
5	Impossibilities	.35
6	Plot Titles (Low Quality)	.58
8	Common Situations	.50
9	Brick Uses (Fluency)	.48
12	Consequences Test (Low Quality)	.64
Factor 12		
24	Apparatus Test	.59
25	Social Institutions (Direct Implications)	.67

Table 17, continued

Factor 13

34	**Word Matrices**	**.30**

Factor 14

15	**Circle Square II**	**.31**
28	**Word Transformation**	**.59**
40	**Disarranged Words**	**.54**
53	**Sentence Gestalt**	**.49**

Table 18

Guilford 09, Model B, Derived Orthogonal Solution

Factor 1		
1	Syllogisms I	.79
2	Syllogisms II	.63
3	Syllogisms III	.70
4	Logical Reasoning	.45
5	Inference Test	.48
7	Sentence Evaluation	.32
12	Verbal Classification	.36
16	Word Selection	.34
17	Evaluation of Comparisons	.32
18	Reading Comprehension	.34
19	Absurdities	.38
26	Sound Grouping	.39
44	Correlate Completion	.37
45	Figure Analogies Completion	.34
Factor 2		
18	Reading Comprehension	.43
36	Ratio Estimation Test	.42
40	Punched Holes	.63
41	Mechanical Principles	.51
42	Ship Destination	.32
43	Arithmetic Reasoning	.62
45	Figure Analogies Completion	.31
Factor 3		
6	Inferences II	.38
18	Reading Comprehension	.30
31	Unusual Details	.75
37	Vocabulary	.32
47	Controlled Association	.62
Factor 4		
18	Reading Comprehension	-.32
20	Object Synthesis	.31
46	Common Situations Test	.65
Factor 5		
21	Object Synthesis II	.53
24	Practical Estimation	.40
Factor 6		
6	Inferences II	.30
34	Figure Estimation (Part I)	.59
36	Ratio Estimation Test	.34

Table 18, continued

Factor 7

7	Sentence Evaluation	.33
9	Critical Evaluation	.42
12	Verbal Classification	.53
13	Word Classification	.33
15	Generalizations	.40
22	Gestalt Transformation	.53
29	Picture Classification	.50

Factor 8

4	Logical Reasoning	.32
25	Social Situations	.46
32	Word Checking I	.63
33	Word Checking II	.73
36	Ratio Estimation Test	.55
42	Ship Destination	.32

Factor 9

20	Object Synthesis	.47
23	Practical Judgment	.47

Factor 10

35	Figure Estimation (Part II)	.60

Factor 11

38	Spatial Orientation Test (Part I)	.40
39	Spatial Orientation Test (Part II)	.54
45	Figure Analogies Completion	.36

Factor 12

4	Logical Reasoning	.34
5	Inference Test	.32
7	Sentence Evaluation	.35
8	Facts and Opinions	.60
9	Critical Evaluation	.42
10	Titles	.36
11	Logical Classification	.63
13	Word Classification	.32
16	Word Selection	.48
17	Evaluation of Comparisons	.32
18	Reading Comprehension	.30
28	Symbolic Judgment	.46
37	Vocabulary	.56

Table 18, continued

Factor 13		
27	Figure Classification	.44
30	Figure Matching	.65
45	Figure Analogies Completion	.41
Factor 14		
2	Syllogisms II	.31
10	Titles	.41
Factor 15		
14	Interpretations	.61

Table 19

Guilford 12, Model D, Derived Orthogonal Solution

Factor 1

11	Contingencies	.34
20	Temporal Ordering	.31
22	Sentence Order	.41
31	Seeing Deficiencies	.35
36	G-Z Verbal Comprehension	.80
37	Vocabulary	.83
41	Inference	.47
45	Controlled Associations II	.38
48	Verbal Analogies I	.39

Factor 2

4	Pertinent Questions	.73
7	Effects	.76
8	Consequences (Remoteness-Parts I, II)	.46
11	Contingencies	.53
13	Planning Skills II	.63
14	Planning Elaboration	.64
15	Figure Production	.44
16	Alternate Methods	.64
18	Symbol Production	.35
26	Unusual Methods	.58
27	Verifications	.45
28	Procedure Applications	.44
31	Seeing Deficiencies	.32
32	Planning Skills	.45
42	Plot Titles (Clever- Parts I, II)	.34
43	Plot Titles (Low Quality-Parts I, II)	.42
44	Consequences (Low Quality-Parts I, II)	.41
45	Controlled Associations II	.39

Factor 3

9	Competitive Planning	.41
12	Route Planning	.52
17	Match Problems II	.64
33	Planning Air Maneuvers	.47
34	Planning a Circuit	.37
35	Code Analysis	.33
46	Match Problems	.66

Factor 4

35	Code Analysis	.30
39	Arithmetic Reasoning	.41
47	Sign Changes	.55
52	Numerical Operations	.68

Table 19, continued

Factor 5		
40	Logical Reasoning	.53
Factor 6		
21	Picture Arrangement	.57
50	Mechanical Principles	-.35
Factor 7		
6	Series	.35
18	Symbol Production	.48
19	Line Drawing	.34
Factor 8		
3	Sensitivity to Order	.53
25	Word Matrices	.31
48	Verbal Analogies I	.34
Factor 9		
10	Symbol Grouping	.44
Factor 10		
51	Symbol Manipulation	.48
Factor 11		
23	Outlining (Part I)	.49
Factor 12		
31	Seeing Deficiencies	.30
49	Practical Judgment	.47
Factor 13		
45	Controlled Associations II	.31
Factor 14		
1	Matrix Order	.34
Factor 15		
30	Ranking of Variables	.50

Table 19, continued

Factor 16		
34	Planning a Circuit	.44
Factor 18		
43	Plot Titles (Low Quality-Parts I, II)	.35
Factor 19		
38	Ship Destination	.51
Factor 20		
24	Outlining (Part II)	.37
Factor 21		
44	Consequences (Low Quality-Parts I, II)	.36
Factor 25		
5	Awareness of Variables	.48

Table 20

Guilford 14, Model D, Derived Orthogonal Solution

Factor 1

1	Balances	.33
3	Circle Square Triangle	.37
5	Form Reasoning II	.34
12	Secret Writing	.42
13	Ship Destination	.57
15	Symbol Manipulation II	.36
19	Aptitude - Spatial	.62

Factor 2

8	Necessary Facts	.31
16	Verbal Comprehension	.76
20	Aptitude - Verbal	.83
22	Mechanics of Expression	.65
23	Reading Comprehension	.59

Factor 3

7	Necessary Arithmetic Operations	.60
17	Aptitude - Quantitative, Part I	.33

Factor 4

4	Essential Operations	.41
6	Logical Reasoning	.43
10	Problem Solving	.54
15	Symbol Manipulation II	.30
23	Reading Comprehension	.32

Factor 5

2	Circle Reasoning	.49
17	Aptitude - Quantitative, Part I	.42
18	Aptitude - Quantitative, Part II	.60

Factor 6

9	Numerical Operations	.52

Factor 7

21	Mathematics Achievement	.49

Factor 8

11	Rules	.39
12	Secret Writing	.37

Table 20, continued

Factor 9		
1	Balances	.35
Factor 10		
5	Form Reasoning II	.51
11	Rules	.32
14	Sign Changes II	.49
Factor 11		
8	Necessary Facts	.31

Table 21

Guilford 16A, Model D, Derived Orthogonal Solution

Factor 1		
2	Completion of Figural Changes	.34
3	Correlate Completion II	.38
10	Inventive Verbal Relations	.65
11	Letter Series	.32
13	Matrix Order	.31
15	Perceptual Relations Naming	.38
16	Picture Classification	.32
19	Seeing Trends II	.43
24	Verbal Analogies I	.45
25	Verbal Analogies Completion	.65
26	Verbal Classification	.47
27	Verbal Relations Naming	.66
28	Word Classification	.39
Factor 2		
9	Form Reasoning	.62
14	Number Series	.38
15	Perceptual Relations Naming	.31
21	Sign Changes	.60
Factor 3		
2	Completion of Figural Changes	.44
5	Figure Analogies	.49
6	Figure Analogies Completion	.63
16	Picture Classification	.32
17	Prescribed Relations	.38
24	Verbal Analogies I	.54
25	Verbal Analogies Completion	.31
28	Word Classification	.39
Factor 4		
5	Figure Analogies	.34
8	Figure Matrix	.49
Factor 5		
18	Seeing Trends	.56
Factor 6		
7	Figure Matching	.46

Table 21, continued

Factor 7

11	Letter Series	.32
20	Ship Destination	.49

Factor 8

1	Circle Reasoning	.56
3	Correlate Completion II	.32
11	Letter Series	.40
12	Letter Triangle	.41
15	Perceptual Relations Naming	.33
16	Picture Classification	.34

Factor 9

3	Correlate Completion II	.35
11	Letter Series	.31
14	Number Series	.49
17	Prescribed Relations	.37
22	Sign Changes II	.48
23	Symbol Manipulation	.57

Factor 10

4	Critical Evaluation	.50

Factor 11

13	Matrix Order	.37

Table 22

Guilford 16B, Model D, Derived Orthogonal Solution

Factor 1

10	Inventive Verbal Relations	.31
23	Vocabulary Completion	.39

Factor 2

4	Correlate Completion II	.33
6	Figure Analogies	.65
7	Figure Classification	.35
8	Figure Matching	.33
9	Figure Matrix	.57
11	Letter Grouping	.36
12	Perceptual Relations Naming	.31
18	Verbal Analogies I	.31
19	Verbal Analogies Completion	.32

Factor 3

10	Inventive Verbal Relations	.36
18	Verbal Analogies I	.53
19	Verbal Analogies Completion	.39
20	Verbal Classification	.32
21	Verbal Comprehension	.52
24	Word Classification	.61
25	Word - Group Naming	.35
26	Word Groups	.35

Factor 4

1	Associations III	.38
2	Associations IV	.60
3	Controlled Associations II	.31

Factor 5

1	Associations III	.41
3	Controlled Associations II	.33
4	Correlate Completion II	.64
10	Inventive Verbal Relations	.31
11	Letter Grouping	.56
12	Perceptual Relations Naming	.43
17	Seeing Trends II	.53
22	Verbal Relations Naming	.37
23	Vocabulary Completion	.48
26	Word Groups	.54

Table 22, continued

Factor 6		
16	Seeing Trends	.49
Factor 7		
5	Critical Evaluation	.52
21	Verbal Comprehension	.42
Factor 8		
10	Inventive Verbal Relations	.38
14	Picture-Group Naming	.48
22	Verbal Relations Naming	.31
Factor 10		
13	Picture Classification	.56

Table 23

Guilford 16C, Model D, Derived Orthogonal Solution

Factor 1

1	Apparatus Test	.79
4	Cartoons	.32
5	Consequences (Low Quality)	.41
6	Consequences (Remote)	.52
7	Controlled Association	.53
8	Controlled Associations II	.62
12	Object Synthesis	.42
15	Plot Titles (Low Quality)	.36
19	Seeing Problems	.70
20	Similarities	.61
21	Social Institutions	.63
22	Unusual Uses	.62

Factor 2

2	Associations III	.66
3	Associations IV	.62
7	Controlled Association	.49
8	Controlled Associations II	.45
9	Gestalt Transformation	.30
10	Letter Grouping	.33
11	Logical Classification	.43
23	Verbal Comprehension	.64
24	Vocabulary Completion	.60
25	Word - Group Naming	.51

Factor 3

11	Logical Classification	.30
17	Remote Verbal Similarities	.44

Factor 4

4	Cartoons	.52
14	Plot Titles (Clever)	.36

Factor 5

18	Seeing Deficiencies	.49
24	Vocabulary Completion	.34

Factor 6

5	Consequences (Low Quality)	.52
15	Plot Titles (Low Quality)	.48

Table 23, continued

Factor 7		
10	Letter Grouping	.46
26	Word Groups	.55
Factor 8		
16	Quick Response	.46
Factor 9		
6	Consequences (Remote)	.30
12	Object Synthesis	.42
Factor 10		
9	Gestalt Transformation	.44
Factor 11		
13	Picture - Group Naming	.39

Table 24

Guilford 22, Model D, Derived Orthogonal Solution

Factor 1		
2	Apparatus Test (Minor)	.37
6	Brick Uses (Shifts)	.60
11	Differences	.36
15	Ideational Fluency	.49
18	Multiple Grouping	.46
20	Object Synthesis III	.59
30	Similarities	.60
Factor 2		
3	Associational Fluency I	.30
16	Logical Reasoning	.59
28	Sequential Association	.41
33	Verbal Analogies I - Part I	.64
34	Verbal Analogies I - Part II	.68
35	Verbal Classification - Part I	.43
36	Verbal Classification - Part II	.47
37	Verbal Comprehension	.49
Factor 3		
3	Associational Fluency I	.32
37	Verbal Comprehension	.43
38	Vocabulary Completion - Part I	.71
39	Vocabulary Completion - Part II	.79
Factor 4		
7	Cartoons - Part I	.30
22	Pertinent Questions	.37
24	Predicaments	.36
25	Seeing Problems - Part I	.61
26	Seeing Problems - Part II	.53
32	Transitions (Logical Aspects)	.56
Factor 5		
7	Cartoons - Part I	.57
8	Cartoons - Part II	.51
Factor 6		
3	Associational Fluency I	.32
19	Object Naming (Shifts)	.38
27	Sentence Pairs	.55
Factor 7		
13	Figure Concepts (Uncommonness)	.55
40	Word Grouping	.48

Table 24, continued

Factor 8		
41	Group Indicator	.62
Factor 9		
42	Random Variable	.52
Factor 10		
5	Attribute Listing II	.53
Factor 11		
9	Common Needs	.55
Factor 12		
12	Episodes	.48
Factor 13		
1	Apparatus Test (Drastic)	.59
Factor 14		
29	Ship Destination Test	.52
Factor 16		
14	Gestalt Transformation	.51
Factor 17		
23	Possibilities	.51
Factor 19		
11	Differences	.37
31	Transitions (Coherence)	.40
Factor 20		
17	Missing Links	.41
Factor 21		
28	Sequential Association	.35
Factor 22		
10	Contingencies	.38

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Table 25, continued

Factor 5		
2	Camouflaged Words	.38
12	Number Relations	.30
17	Ordering I	.58
23	Verbal Comprehension	.48
30	Word Transformations	.36
Factor 6		
20	Seeing Trends II	.36
27	Word Groups	.42
Factor 7		
13	Number Series Correction	.36
Factor 8		
6	Letter Analogies	.37
Factor 9		
9	Limited Sums	.44
12	Number Relations	.39
14	Numerical Operations	.58
16	Operations Sequence	.43
Factor 10		
28	Word Patterns	.47
Factor 11		
22	Symbol Grouping	.30
Factor 12		
5	Four-Letter Words	.33